# SCIENTIFIC RESEARCH

# AND

# RESEARCH TRAINING

# IN

# BASIC SCIENCES

1980

INDIAN NATIONAL SCIENCE ACADEMY
Bahadur Shah Zafar Marg, New Delhi-110 002

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# SCIENTIFIC RESEARCH AND RESEARCH TRAINING IN BASIC SCIENCES

This Report contains the brief account of progress achieved during the year 1979-80 in the ongoing projects supported by the Academy, based on the information supplied by the project-investigators.

INDIAN NATIONAL SCIENCE ACADEMY
BAHADUR SHAH ZAFAR MARG, NEW DELHI

1980

## Contents


| | | Pages |
|---|---|---|
| 1. | Introduction ..... .. | iii - iv |
| 2. | Section I Physical Sciences | 1-62 |
| | Mathematics | 1-26 |
| | Physics | 27-44 |
| | Chemistry | 45-62 |
| | Section II Biological Sciences | 63-144 |
| | Botany | 65-73 |
| | Zoology | 75-94 |
| | Biochemistry | 95-105 |
| | Medical Sciences | 107-121 |
| | Agriculture | 123-144 |
| | Section III Engineering & Earth Sciences. | 145-163 |
| | Engineering | 147-153 |
| | Geology | 155-163 |

## INTRODUCTION

The Indian National Science Academy is the recognised premier scientific organisation in the country representing all branches of sciences. One of the main objectives of INSA is to promote the development of natural knowledge in India including its practical application to problems of national welfare. Various agencies like CSIR, DAE, ISRO, DRDO, ICAR and ICMR provide funds for research in areas relevant to the objective of the corresponding agencies. With a view to promoting the basic research in the country, the Government entrusted in 1969 to the Academy a Scheme entitled 'Scientific Research and Research Training in Basis Sciences'. The support provided by the Academy has helped some institutions in carrying on the research activity and also training of research personnel in different fields of science. Currently about 100 research schemes are in progress in various academic institutions wherein about 500 research workers are engaged.

The categories of research projects supported under this scheme are as follows :

1. Inter-disciplinary and inter-institutional research projects in the identified and well defined areas involving fundamental research.

2. Projects belonging to 'Frontier Science'.

   These may deal with problems far removed from human environment, with minor social relevance. They may have no obvious application of immediate importance, as they would deal with phenomena which belong to a different area in which only the scientists may see and evaluate their fundamental nature.

3. Mission-oriented projects

   These concern problems of a basic nature, leading to improvements in technology and consequent saving of foreign exchange by import substitution and export promotion.

4. Projects involving composite scientific expeditions and field studies in regions of the Indian Union which have not so far been explored.

5. Projects mainly concerned with human Environment

   Such projects will involve several scientific disciplines. These may be problems of basic or pure science with the object of discovering or elucidating phenomena, without insisting on immediate practical application. Even so, they may be of relevance to some medical or technological problems with profitable impact in applied fields.

Contd....

6. Research projects by young scientists medal awardees.

Since 1974, the Academy has instituted Science Academy Medal for Young Scientists below 30 years of age. The awardees of this Medal are supported in their research efforts by providing funds for contingencies/consumables.

7. Status reports in the well-delineated areas.

The Academy also supports the preparation and publication of state-of-art reports and for writing research monographs.

Priority is given to research falling under basic sciences which attempt to solve the problems of national needs, newer fields and inter-disciplinary in nature in the identified areas.

The Academy identifies areas of research in the context of national development in all branches of science through suggestions invited from the Fellowship, Sectional Committees and the National Committees.

At present, the Academy is supporting research in the following priority areas :

1. Transition from laminar flow to turbulence.
2. Non-linear phenomenon in plasma waves and instabilities.
3. Unconventional energy resources.
4. Catalysts.
5. Cellular organelles.
6. Growth differentiation in normal and cancer cells.
7. Hormonal control of flowering and fruiting including forest trees.
8. Insect, Pest and Bird Control.
9. Leprosy.
10. Genetics and behaviour.
11. Wind forces on tall and slender structures.
12. Solid State chemistry.
13. Basic problems of Fish Nutrition, Genetics and Hybridisation.
14. Genetics of Biological Nitrogen Fixation.
15. In Vitro Culture of Steriod yielding plants.
16. Mechanism of Pain.
17. Basement Cover Relations in the Precambrian orogenics of Rajasthan and Mysore.

# I

# PHYSICAL SCIENCES

1. MATHEMATICS
2. PHYSICS
3. CHEMISTRY

## MATHEMATICS

| | Title of the Project | Name of Investigator(s) and Institutions. |
|---|---|---|
| 1. | Inter-institutional project on 'Wave Prepagation in Plasma'. | Coordinator<br><br>Prof. S.K. Trehan,<br>Punjab University,<br>Chandigarh.<br><br>Investigators:<br><br>Prof. D.K. Sinha,<br>Jadavpur University,<br>Calcutta.<br><br>Prof. R.S. Kushwaha,<br>Jodhpur University.<br><br>Dr. K.M. Srivastava,<br>University of Roorkee,<br><br>Prof. M.S. Sodha,<br>IIT, New Delhi.<br><br>Prof. J.N. Tandon,<br>Delhi University.<br><br>Dr. M. Lakshmanan,<br>University of Madras,<br>Tiruchirapalli.<br><br>Dr. Som Krishna,<br>IISc, Bangalore.<br><br>Dr. R.K. Chhajlani,<br>Vikram University,<br>Ujjain. |
| 2. | Inter-institutional project on 'Transition from Laminar Flow to Turbulence'. | Coordinator<br><br>Prof. N. Rudraiah,<br>Bangalore University.<br><br>Investigators:<br><br>Dr. Mihir B. Banerjee,<br>H.P. University,<br>Simla-5. |

| 1. | 2. | 3. |
|---|---|---|
| 2. | | Prof. R.S. Nanda and<br>Prof. A.S. Gupta,<br>IIT, Kharagpur. |
| | | Dr. R.K. Jain,<br>IIT, Kanpur-16. |
| | | Prof. A.P. Verma,<br>S.V. Regional College<br>of Engg. & Technology,<br>Surat. |
| | | Dr. M.N. Channabasappa,<br>KREC, Surathkal(Karnataka) |
| | | Prof. R. Narasimhan,<br>IISc, Bangalore. |
| 3. | Project on 'Unsteady motion in Fluid Dynamics. | Dr. P. Mohapatra,<br>Utkal University,<br>Vani Vihar,<br>Bhubaneswar-4. |

# Studies in nonlinear effects in the problems of wave propagation and stabilities in semiconductors with plasma stream.

D. K. Sinha
Jadavpur University, Calcutta

One of the main areas of studies in solid state plasmas is to investigate interactions between different quasiparticles in semiconductors and such studies are becoming prominent with the proliferation and fabrication of these materials. The present investigation is aimed towards this end and seeks to investigate, following a classical approach, propagation of waves in semiconductors and, in particular, in piezosemiconductors caused by apposite excitations. A limitation in most of the studies relating to propagation of waves in piezosemiconductors is to consider the amplitude of waves to be small and this enables us to linearize nonlinear equations (arising mainly out of space charge nonlinearity). But such an approximation would not be valid if the amplitude is not small enough and one has then to accomodate the nonlinear effects in the investigation. One aspect of nonlinear studies, namely, parametric interaction of acoustic waves in piezosemiconducters has been treated in depth for a particular problem. The basic equations are essentially the equations of electricity and of mechanical motion aided by the constitutive equations of piezoelectric media. To facilitate analytical solution two assumptions are made, viz. the electron drift velocity to be exactly equal to sound velocity and the pump energy loss due to nonlinear interaction to be negligible. The theoretical investigation shows conclusively that there is a gain of energy of signal wave at least at the initial stages of propagation due to a pump wave whatever be its amplitude (the amplitude is, of course, large compared to that of signal wave). It has also been possible through this investigation to identify a certain region for the amplitude of pump wave for which there is always gain of energy of signal wave. In another attempt which is still under way, we have sought to extend the study on parametric interaction by taking into account the effect of heating of electrons by applied d.c. electric field. Similar studies are also being taken up for harmonic generation of waves.

# Non-linear phenomena in plasma waves and instabilities

K. M. Srivastava
University of Roorkee, Roorkee.

1. Plasma wall interaction and instabilities in confinement devices:

Some non-linear effects in the plasma flow and stability of the thermonuclear plasma in confinement devices near the outer boundary of the plasma column and the confining walls have been proposed to be investigated.

Following types of problems have been proposed to be investigated:

(i) Plasma flow and electric field effects in the scrape off layer.

(ii) Non-linear treatment of plasma diffusion and stability.

2. Effects of non-linearity and inhomogeneity on MHD waves and instabilities.

Effects of inhomogeneity, non-linearty and finite amplitude perturbation on MHD waves, thermal convection, Rayleigh-Taylor, Kelvein-Helmohtz instabilities have proposed to be studied.

Problem of thermal convection instability whose motivation comes from the problem of convective interchange instability of toroidal fusion plasmas confined in a strong-magnetic field will be disscussed in cylindrical toroidal geometry. The dynamics of two and three-component inhomogeneous plasmas may also be investigated which has application in confinement devices as well as in Astrophysics.

Achievements of work done has been put in the form of following research papers:

1. Two fluid theory of divertor scrape-off layer with ion magnetic Gyroviscosity:

We have studied the two dimensional problem of the dynamics of the scrape-off layer with a poloidal divertor-through the two fluid equations including the effect of finite ion temperature.

2. Non-linear Kelvin Helmholtz magnetohydrodynamics instability of a rotating plasma:

In the paper we have studied non-linear analysis for Kelvin Helmholtz instability of an incompressible inviscid rotating fluid with infinite conductivity in the presence of gravity and surface tension.

3. Thermal oscillations in the presence of suspended particles:

The problem of thermal convection instability of a horizontal layer of fluid and the suspended particles has been studied in the presence of both vertical and horizontal temperature gradients.

4. Thermal convection instability of a liquid metal in MHD:

The problem of thermal convection instability of a horizontal layer of fluid in MHD has been studied in the presence of both vertical and horizontal temperature gradients.

5. Pulsatile flow of suspended particles through a constricted tube:

The pulsatile flow of a viscous-incompressible fluid embedded with small identical spherical particles through a locally constricted tube is studied in view of its importance in arterial diseases.

6. Mass transfer in a Hemodializar with induced magnetic field:

A model for two phase co-current motion with a circular interface has been developed for estimating the transfer processes in a tubular hemodializar with induced magnetic field.

# Nonlinear interaction of electromagnetic waves with plasmas

M. S. Sodha
Indian Institute of Technology, New Delhi.

Most of the available investigations on the excitation of the electrostatic modes and stimulated scattering are limited to the pump waves having uniform intensity distribution along their wave front. But in laser induced fusion, Gaussian beams are commonly used. When the beam is having Gaussian intensity distribution along its wavefront ponderomotive force becomes finite and leads to redistribution of the carriers. If the initial power of the becam is more than the critical power for self focusing, the beam gets self-focused and hence the available theories on mode excitation and stimulated scattering become non-applicable. We have extensively studied the excitation of the electrostatic modes and the stimulated scattering when the pump wave is having Gaussian intensity distribution. On account of Gaussian intensity distribution of the pump wave, the electrostatic mode and the pump wave get coupled through the modified back ground electron density and the excitation process is considerably affected. It is seen that the self focusing of the pump further leads to considerable modification of the power of the excited plasma wave. When the phase matching conditions are satisfied the excited plasma waves lead to enhanced stimulated Raman scattering and the self-focusing of the pump wave enhance the scattered power. Because the conditions for the excitation of the stimulated Brillouin scattering (SBS) can be easily satisfied in the under dense plasma, therefore SBS affects the coupling of the laser energy with the plasma it is seen that the ion acoustic wave is also excited and it again interacting with the laser beam leads to enhanced Brillouin Scattering.

Besides the excitation of the electrostatic waves by a single pump wave we have also investigated the excitation of the electrostatic waves viz. electron plasma waves, ion acoustic waves, upper hybrid waves, lower bybrid waves, electrostatic drift waves and ion cyclotron waves by two co-axial Gaussian beams. In addition to this the transient setting of ponderomotive nonlinearity in plasma has also been studied.

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# Magneto-rotating Plasma: Application to Astrophysical Phenomena

J. N. Tandon
University of Delhi, Delhi.

The velocity field and magnetic field terms in the plasma dynamics equations are primarily responsible for the non-linear behaviour of plasma. Such terms are fairly significant for exploring most of the laboratory and astrophysical phenomena. Recently, some positive attempts have been made in this direction but are primarily of academic interest and significant approach has not yet been made to explore some specific phenomena.

In this project emphasis was laid to explore the contribution of these non-linear terms in actual astrophysical and solar situation.

We have investigated the effect of rotation and of magnetic field separately on the equilibrium structure of a wholly convective model of an early type star in the H-R diagram with significant radiation pressure. The effect of these parameter on the various equilibrium parameter i.e. mass, radius, central condensation etc. have been computed for the case of rotating non-magnetic star and non-rotating magnetic star. Further using the earlier model of magneto-rotating star we have developed a new triggering mechanism for stellar flare on M-dwarf stars.

On solar inter planetary dynamic front, the inter correlation of large scale coronal structures and solar wind have been quantitatively explained through the focussing of solar-ion streams taking into account of the local and general solar magnetic fields. Some of the outstanding problems relating to solar wind-magnetospheric interaction have been identified and reviewed.

# "Nonlinear Wave Propagation Phenomenon in Ferromagnetic System"

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During the past decade, it has been established that a class of physically interesting nonlinear dynamical systems possess remarkably stable soliton states and are completely integrable. These systems are characterized by equations of motion which are nonlinear partial differential equations in one space and one time dimensions and which are dispersive. Examples of such cases are the ionacoustic wave propagation in plasma physics described by Korteweg-de Vries equation, Voltage propagation across a Josephson junction described by the sine-Gordon equation, etc. Recently we have shown that the continuum limit of the linear Heisenberg ferromagnetic spin system described by the Hamiltonian $H = -J \sum \vec{S}_i \cdot \vec{S}_{i+1} + \mu H \sum_i S_{iz}$, involving nearest neighbour interactions is exactly solvable and is equivalent to a nonlinear Schrodinger equation and is thus completely integrable and belong to the above class. To be more realistic and to compare with experimental situations, it is important to analyse the above system in the three-spatial dimensional situation for the continuum limit as well as the discretized system for high temperatures. Thus the object of this scheme is to analyse nonlinear wave properties corresponding to the three-dimensional continuum system satisfying the equations of motion for the spin in the form

$$\frac{\partial \vec{S}(\underset{\sim}{r},t)}{\partial t} = \vec{S} \times \vec{\nabla}^2 \vec{S}, \quad \vec{S}^2 = 1,$$

and for the discrete case,

$$\frac{d\vec{S}_i}{dt} = \vec{S}_i \times \sum_{\{j\}} \vec{S}_j, \quad \vec{S}_i^{\,2} = 1.$$

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In particular we wish to expore whether these systems are also solitonic in nature and completely integrable. Then the question of evaluating various thermodynamical quantities and magnetic properties is to be explored. Finally, the quantization of these systems is of practical relevance.

In the first phase of this project, we have analysed the stationary limit of the three-dimensional ferromagnetic system and shown its close analogy with the Ernst equation in general relativity describing uniformly rotating axially symmetric source. From this analogy we have proceeded to solve explicitly the cases corresponding to spherical and axial symmetry. It was established that there exists stationary standing spin waves as well as localized particle-like solutions in these cases. The time evolution of the spherically and circularly-symmetric cases were mapped on a helical space curve obeying Serret-Frenet equations of differential geometry and invariant sets of equations in the form of modified nonlinear Schrodinger equations with X-dependent terms were derived. From the underlying basic SL (2,R) structure, an algebraic structure common with other soliton possessing equations was derived. By considering the Taylor expanded version of the equation of motion, the discrete system itself was shown to share these properties and thereby indicating its complete integrability. Our present efforts are directed on the problem of studying the structure of correlation functions and dynamical structure factors using the above results and evaluating magnetic properties.

## Non-Linear Plasma Theory Design and Fabrication of Diagonistic tools for not very high density Plasmas

Dr. Sam Krishna,
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The project has theoretical and experimental components. In the theoretical side, non-equilibrium plasma phenomena are intended to be studied by statistical methods. The applications that are under way relate to a) Laser-plasma interactions, b) X-ray emission and density thresholds, and c) parametric decay instabilities. On the experimental side, the aim is to apply mass spectrometric techniques to plasma diagnostics.

The actual studies carried out so far, refer to discharge and spark plasmas, which exhibit several of the above features. A quadrupole mass spectrometer has been constructed for studies on ionic composition of discharge plasmas. This has been used for studies on oxygen discharges, characterized by two different modes, and the positive and negative ionic compositions in these modes have been measured and correlated with Langmuir probe studies. Another set of studies relates to the much-debated mechanisms of initiation of a vacuum spark. The d.c. vacuum spark has been studied with respect to ionic composition and charge states, and the data lend definitive support to anode breakdown theories. Further measurements of charge states etc., are under progress to elucidate other aspects to this phenomenon.

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# A STUDY ON NONLINEAR WAVES IN PLASMA.

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The problems of basic plasma physics play a very important role in the development modern physics. In this direction, the nonlinear phenomena in plasma have attracted an increasing interest in recent years. The extensions of present state of non-linear plasma physics to include new idea is at present a challenging programme.

In discussing nonlinear phenomena, it has been shown that the reductive parturbation method applied with success to the fluid model of collisionless plasma. In present investigation we shall try to extend this method for some problems of theoretical interest. Lashmore-Davis has considered the nonlinear interaction of a few coherent, weakly coupled longitudinal and transverse waves in an unmagnetized plasma by means of coupled mode theory. It is proposed to carry out some investigations in this direction.

From many recent investigations, it has become clear that even weak nonlinear interaction can drastically affect the stability of waves as computed from linearized theory. Hence more and more cases of such nonlinear interactions are treated in plasmas. In this direction Verheest has discussed the possible nonlinear wave-wave coupling between three or four waves in plasmas. He has used a multiple time scale method for separating the linear and nonlinear parts of the equations. In our study, we propose to extend this investigation on nonlinear wave-wave coupling between three or four waves in plasma and also in other media under different situations.

We are presently carrying out an investigation on the nonlinear interaction of plasma waves due to electron beams. We are also discussing three wave interaction in magnetized plasma.

In the proposed study, we will also try to describe situations which have been yet outside the scope of theoretical analysis but which are most likely prevalent in many experiments.

# Transition from Laminar Flow to Turbulence.

N. Rudraiah
Bangalore University,
Bangalore.

The linear and local-nonlinear stability of thermal convection in fluid saturated porous media, subjected to uniform and non-uniform temperature gradients is investigated. The critical Rayleigh number at the onset of convection and the corresponding heat transfer are also determined. An approximate analytical method is presented to determine the form and amplitude of convection. To facilitate the determination of the physically preferred cell pattern, a detailed study of both two-and three-dimensional motions is made and very good agreement with the available experimental data is found. The finite amplitude effects on the horizontal wave number and the effect of Prandtlx number on the motion are discussed in detail. It is shown that when the Rayleigh number is just above the critical value the two-dimensional motion is likely to appear than the three-dimensional motion and heat transport has two regions. In particular it is shown that optimum heat transport occurs for mixed horizontal plan-form formed by the linear combination of general rectangular and square cells. Since infinite number of steady finite-amplitude solutions exist above the critical Rayleigh number, a relative stability criterion is discussed which selects that solution as the realized solution which has the maximum square temperature gradient. / more

In the case of non-uniform temperature gradient arising from either sudden heating or cooling, a simple Galerkin method is used and different basic nonlinear temperature profiles are discussed. It is shown that the most destabilizing temperature gradient is one for which the temperature gradient is a step-function of the depth. On the other hand the most stabilizing temperature gradient is the inverted parabola. The effect of Coriolis force is also discussed and it is shown that it inhibits the onset of convection in the marginal state. The physical reason for setting up of oscillatory convection in the presence of Coriolis force is also described.

# Nonlinear Hydrodynamics Just Past Linear Equilibrium

Mihir B. Banerjee
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Simla.

In the present work we attempt to establish and solve the simplified nonlinear governing equations just past linear equilibrium for hydrodynamical problems. A dimensional argument is given in this context for the case of simple Benard problem and it follows as a consequence that the pattern of motions which first appears at marginal stability continues to manifest itself just past it also with the amplitude growth governed by Landau's (1944) conjecture. Subsequently, a theoretical interpretation of the experimental findings of Malkus (1954) is given which is based on these equations. It is clear during the course of the analysis that the basic ideas underlying the present argument are of wider generality than the simple context in which they are presently stated.

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A br **Transition from Laminar Flow to Turbulence** -oject

A.P. Verma
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It was envisaged in the project to undertake the study of problems which may be classified in two categories: (i) Basic systems and (ii) Instabilities. The work since 1.3.1977 has been concentrated to the study of various coupled phenomena in polyphase flow in porous media like instabilities, simultaneous flow of immiscible liquids and Dispersion. Instabilities are the protuberances in interface which arise when a fluid contained in a porous medium is displaced another of lesser viscosity. This phenomenon is vital in the secondary recovery processes in oil reservoir engineering. Previous authors have given several types of analytical solutions for showing the stabilization of fingers and no numerical support was given by them. We have applied numerical technique (finite difference) for obtaining the numerical solutions of this problem by incorporating some modified assumptions. The statistical behavior of fingers in two phase flow in the presence of magnetic field has also been investigated and results were presented in 2nd Multiphase flow and Heat Transfer Symposium at Florida, U.S.A. Various more interesting results for the nonlinear behavior of instabilities have been obtained.

Investigation of dispersion phenomenon in heterogeneous porous media has been made. A singular perturbation technique of matched asymptotic expansions have been used to obtained concentration distributions that result when point source injects a finite volume of radioactive tracer in an aquifer of variable characteristics. It is assumed in the analysis that the recharge well maintains concentration as a function of time for a finite time period. Plots of some typical concentration distributions for outer solutions for different values of t are shown in Fig. '. It is noted that the concentration distributions have discontinuities at both the front and rear of the concentration wave. It is also concluded that the

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radio-active decay constant affects only the height of the concentration wave and that the width of the profile decreases independently of $\lambda$ (radio-active decay constant) as x increases. Comparision of Figs. 2 and 3, which are plotted for inner solutions for front and rear of the profiles for t = 3 and t = 4 respectively, that the length of the transition zones $F_1F_2$ and $R_1R_2$ increase as time increases. Comparision of Figs. 1 and 4 gives that the dispersion changes the concentration distribution mainly near the front and rear of the profile respectively.

The problem of motion of two immiscible liquids in a medium consisting of branched system of cracks varying in the orientation has been discussed. New expression for the inpregnation function which gives the amount of water sucked into the blocks has been derived. The simultaneous flow of two immiscible liquids in a porous medium is investigated. Finite difference technique has been used to obtain approximate numerical solution of the problem.

Instabilities in diphasic flow have been investigated only in heterogeneous porous media by using numerical and analytical techniques. Recently, Scheidegger (J. Hydrology, 1970) has derived stability conditions for fingering processes in homogeneous porous media. It was decided by us to investigate this problem numerically for getting the more new aspects of fingers. The mathematical formulation yielded a nonlinear p.d.e. of the form

$$\frac{\partial}{\partial x}\left[\frac{KDS(1-S)}{\mu_w\left(Sm+(1-S)\right)}\frac{\partial S}{\partial x}\right] = \frac{Vm}{(S(m-1)+1)^2}\frac{\partial S}{\partial x} + P\frac{\partial S}{\partial t} \quad (1$$

The initial and boundary conditions were taken as

$$S(x, 0) = 0 \qquad ..(2)$$

$$S(..,t) = 0 \qquad ..(3)$$

$$S(0, t) \leq 0; \quad t \leq 0 \qquad ..(4)$$

$$= 1, \quad t > 0$$

In the above, K = permeability of the medium; $\beta$ = coefficient of capillary pressure; V = velocity of injection of water; S = saturation of the injected phase; t = time; $\mu_w$ = viscosity of water and $\mu_o/\mu_w$ (mobility ratio).

Equation (1) was converted into finite difference scheme by using Crank-Nicolson method. A computer program was prepared for obtaining its numerical solution. During the computation it has been found that numerical difficulties are encountered in the regions where the saturation gradients become large. In this region the coefficient of second derivative becomes very small and hence the differential equation reduces into a singular perturbation problem. Thus the solution in this region is impossible to obtain by ordinary numerical techniques. Therefore it is proposed to develop a new technique for obtaining the solutions of such problems in which numerical difficulties occur due to discontinuity in the initial and boundary conditions.

# TRANSITION FROM LAMINAR FLOW TO TURBULENCE

M.N. Channabasappa
Karnataka Regional Engineering College,
Surathkal.

The study of stability of fluid flow through and past porous media is important on account of its relevance to many problems encountered in engineering practice. In particular Couette flow (plane as well as rotational) plays an important role in lubrication theory.

The main objectives of the research project are :

(i) to determine experimentally the breakdown of laminarity in the Poiseuille, free and plane Couette flows, with one of the boundaries being a porous bed with given inclination;
(ii) to investigate theoretically and experimentally the stability of Couette flow between two rotating circular concentric cylinders where the inner cylinder is provided with a porous lining.

The following is the progress made in respect of the first problem: An experimental unit fabricated (plate) for the purpose is a tilting flume with an approach section, and a rectangular glass walled channel 140 cm. long and 20 cm. wide, with all necessary devices for measuring pressure gradient, the mass flow, velocity of the upper plate in the case of plane Couette flow, etc. The porous media used are matrices of graded sand in five types, the physical properties of which are determined through auxiliary experiments. The critical Reynolds numbers for all these types of flows are obtained for one type of sand for different inclinations and gaps. The completion of the experimental programme for different porous media would enable us to correlate the critical Reynolds numbers with the various parameters of the porous media.

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EXPERIMENTAL RESULTS

| Type of flow | Slope of the bed | Definition of Reynolds number | Critical Reynolds number at which laminarity breaks down | |
|---|---|---|---|---|
| | | | Smooth Impermeable bed | Porous bed ($S_3$) |
| Poiseuille | $\theta = 0°$ | $R = \frac{\bar{V}\, 2h}{\nu}$ ($\bar{V}$ = Ave. velocity) | 2000 | 1500 |
| Free | $\theta = 30'$ | $R = \frac{\bar{V}\, h}{\nu}$ | 540 | 420 |
| | $\theta = 1°$ | | 630 | 540 |
| | $\theta = 1°30'$ | | 720 | 600 |
| Couette | $\theta = 0°$ | $R = \frac{u_c\, h}{2\nu}$ ($u_c$ = centre-line velocity) | 490 | - |

The following is the progress made in respect of the second problem :

The basic flow in the annulus has been obtained using the Beavers and Joseph (1967) slip-boundary condition. The application of linear stability analysis has led to a sixth order boundary value problem with eigen values. Since the usual no-slip conditions are not valid at the porous boundary on account of a non-zero transverse velocity, appropiate boundary conditions have been obtained taking into account the coupling of the disturbance fields in the annulus (free flow) and in the porous material. The numerical solution of the system is being attempted using the Runge-Kutta-Gill method treating the boundary value problem as an initial value problem, with necessary corrective procedures. Experimental verification of the theoretical results is also planned wherein we would like to consider different porous materials, cylinder speeds, gaps and fluids.

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# Transition from laminar flow to turbulence

R. Narasimha
IISc, Banglore

## 1. Experiments on transition

A series of experiments, conducted on transition from laminar to turbulent flow in boundary layers subjected to pressure gradient, have been completed and analysed. A major finding is that the effect of the pressure gradient can only be understood in terms of the Reynolds number at which instability sets in; the nature of the intermittancy distribution obtained during transition depends on the location of the critical Reynolds number point in relation to the pressure gradient distribution. A detailed technical report on these studies is being prepared.

## 2. Reverse transition

A variety of flow visualization experiments have been conducted to demonstrate the phenomenon of reverse transition from an originally turbulent flow to eventually laminar flow. Following the identification of three classes of reversion made earlier /1/, experimental work on visualization of the flow in each of these three classes has been done. This work has been published /2/.

## 3. Relaminarizing flows

A comprehensive survey and analysis of all situations has been made /3/. Based on this, it is proposed that the phenomenon is governed by one or more of three classes of mechanisms. In the first, turbulence energy is dissipated through the action of a molecular transport property like the viscosity or conductivity, and the governing parameter is typified by the Reynolds number. In the second class, turbulence energy is destroyed by work done against an external agency, like buoyancy forces or flow curvature; the typical parameter is a Richardson number. In both cases experimental evidence indicates that the suppression of turbulence goes beyond the mere decay of energy to an actual decorrelation of the velocity components contributing to the crucial Reynolds shear stresses that govern the mean flow.

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The third class of reverting flows is exemplified by a turbulent boundary layer subjected to severe acceleration. Here a two-layer model is suggested. In the outer layer turbulence is fairly rapidly distorted and the Reynolds shear stress is nearly frozen; the inner viscous layer exhibits random oscillations in response to the forcing provided by the remnants of the original turbulence. Reversion here is not so much the result of dissipation or destruction of energy (although these mechanisms are also operating), but rather of the domination of pressure forces over slowly-responding Reynolds stresses, accompanied by the generation of a new laminar boundary layer stabilized by the acceleration.

In many of these reverting flows, the magnitude of the observed effect is much larger than what might be expected from naive estimates of energy balance. It is suggested that the explanation is that one is here interfering with the organization of motion in the large scale coherent structures now believed to be present in turbulent shear flows. A fuller understanding of the nature of such organized motion is likely to provide more precise tools for engineered reversion and turbulence control.

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# Unsteady motion in fluid dynamics

P. Mahapatra
Utkal University, Bhubaneswar

The aim of the project was to compile a bibliography of all available papers on unsteady motion in Fluid dynamics and to study problems on unsteady motion of different types of fluids, with specific stress on Magne-to-hydrodynamic flows.

A bibliography of five hundred eight papers on unsteady motion has been compiled. Nine problems have been solved, namely, (i) Oscillatory flow past a porous flat plate, (ii) Visco-elastic flow formation in couette motion, (iii) Unsteady Visco-elastic flow between two parallel plates moving in opposite directions, (iv) Oscillatory radial flow of a second order liquid between parallel plates, (v) Hall effect on couette flow, (vi) Magnetohydrodynamic flow near an infinite plate, (vii) MHD flow engendered by the time varying motion of a plate, (viii) Effect of Hall current on Hydromagnetic flow near an accelerated wall and (ix) Magnetohydrodynamic flow pastan oscillating magnetized plate, when Hall effect is taken into account.

In the paper 'Oscillatory flow past a porous flat plate", the oscillatory flow of a fisco-elastic liquid past a stationary porous flat plate, when the free stream oscillates haronically with the velocity $U_o \cos wt$, has been studied. Perturbation method has been applied to obtain solution.

"Visco-elastic flow formation in Couette motion deals with the Couette motion of an elastico-viscous liquid between two parallel porour infinite flat plates, one of which is at rest and the other starts impulsively from rest. Laplace transform technique and Perturbation technique have been applied to derive the solution.

The flow of a Visco-elastic liquid between two parallel plates, which suddenly start moving with equal velocity in opposite directions has been studied in the paper entitled "Unsteady Visco-elastic flow between two parallel plates moving in opposite directions".

'Oscillatory radial flow of a second order liquid beteen two parallel plates" deals with the laminar radial flow of a second order visco-elastic liquid due to an oscillating source, between parallel plates, when the source strength Q is given by $Q = Q_o \cos wt$.

The paper entitled "Hall effect on couette flow" studies the effect of Hall current on the motion of a viscous liquid between two parallel electrically non-conducting plates.

The paper 'Magnetohydrodynamic flow near an infinite plate" deals with the flow of an electrically conducting viscous liquid due to the time varying motion of an infinite plate.

We have studied the MHD timedependent flow of a viscous electrically conducting luquid past an infinite plate in the paper entitled 'MHD flow engendered by the time-varying motion of a plate.

An analysis of the flow of a conducting fluid near an accelerated porous wall has been carried out, taking Hall currents into account in "Effect of Hall current on hydromagnetic flow near an accelerated wall",

In the paper 'Magnetohydrodynamic flow past an oscillating magnetized plate, when Hall effect is taken into accomnt", the flow of an electrically conducting liquid past a magnetized oscillating plate has been studied, when Hall currents are taken into consideration.

Contributions to Science

In view of the several important applications of Magnetohydrodynamics, namely, various energy conversion or storage devices, magneto the rapy, Magnetohydrodynamic power generator, and applications in space propulsion, is expected that the papers on Magnetohydrodynamics will prove to be significant contributions to Science. Moreover, the visco-elastic fluids are used in chemical and process Industries and as such the visco-elastic flow problems are likely to have Industrial and Technological applications.

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# PHYSICS

# PHYSICS

## PHYSICS

| Title of the Project | Name of Investigator(s) and Institution(s). |
|---|---|
| 1. Inter-institutional Project on 'Exploitation of Unconventional Energy Resources'. | Coordinator<br>Prof. L.S. Kothari, Delhi University.<br>Investigators:<br>Dr. C.M. Singal, Roorkee University.<br>Dr. Suresh Chandra, Banaras Hindu University, Varanasi.<br>Dr. S.K. Chattopadhyaya, Kurukshetra University.<br>Prof. M.S. Sodha, IIT, New Delhi.<br>Dr. V.K. Tewari, BITS, Pilani.<br>Dr. Hiranmoy Saha, Kalyani University.<br>Prof. P. Krishna, BHU, Varanasi.<br>Dr. D.N. Bose, IIT, Kharagpur-3.<br>Prof. V.R. Krishnan, S.V. University College of Sciences, Tirupati (A.P.) |
| 2. Investigations of Interstellar Molecules. | Prof. S.N. Ghosh, Calcutta University. |
| 3. Splat quenched versus vapour deposited Amorphous Materials-preparation and characterisation. | Dr. V.D. Vankar, IIT, New Delhi-29. |

# Theoretical and Experimental Investigation of p n junction solar cells and MOS Solar cells.

G.P. Srivastava and L.S. Kothari
Delhi University, Delhi

In the recent years MOS (Metal-oxide-semiconductor) solar cell has been reported as a low cost alternative to pn junction solar cell because of the fact that its technology is much simpler and the efficiency is comparable with that of a pn junction solar cell. It is expected that MOS solar cell will soon find use in terrestrial applications.

We have developed a general theory of MOS solar cell by making necessary modifications in the earlier theories given by Fonash, Green, Card and Yang. Following are the important modifications:-

(i) The concept of surface states given by Card and Rhoderick has been modified by considering surface states of density $D_s$ per $m^2$ as a whole.

(ii) The idea of tunnel transmission co-efficient has been introduced by considering the tunneling effective mass of the carriers.

(iii) The tunneling currents through the surface states have been considered which the earlier workers has neglcted.

The theory presented by us explains fairly well the experimental results and the experimental trends observed by by Ponpon and Siffert, Stirn and Yeh, Lillington and Townsend - that there is anaptimum thickness of the oxide layer '$\delta$' for which the power output from a MOS solar cell is maximum. However, a discrepancy has been found in the value of '$\delta$' for Au-Sio2 -nsi system for which we have done the calculations (($\delta$ opt.)) expt. $\sim$ 20 AO and and (($\delta$ opt.)) theory $\sim$ 10 A°. This discrepancy has, however, been resolued to great extent by considering the non uniformity of the thin oxide layer (10-40 A° i.e. a few molecular distance only) because the simple statistics

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can show that for such a small thickness growth can't be uniform. It has been found that the thickness has a Gaussian distribution in the range of our interest (10-40 A°). Also the tunnel thickness is always lesser than the average thickness.

Theoretical investigations are being carried out on high intensity effects on the performance of MOS solar cell and it is found that the saturation of photovoltage starts taking place when intensity is nearly 800 suns.

On the experimental side the behaviour of pn junction solar cell is being studied at very high intensities of illumination using Ruby laser. It has been noticed that initially photovoltage increases with increasing intensity, then it remains constant for certain range of illumination and then it starts decreasing on further increasing the intensity of light.

Two Experiments for the measurement of life time of monority carries have been set -$V_{oc}$ decay method and open circuit to short circuit switching method. We propose to study the effect of various physical conditions on the life time of the minority carries.

# Study of Photovoltaic Power Conversion Process in Silicon Solar Cells.

C. M. Singal,
University of Roorkee,
Roorkee.

## PRECISE OBJECTIVE OF THE PROJECT

To identify the various physical processes that limit the Photovoltaic Power Conversion efficiency of Silicon Solar Cell and to established experimental method of these processes based on suitable theoretical models. Finally, to make appropriate modification in the Solar Cell fabrication process to overcome, as much as possible, these efficiencies limiting physical processes.

## ACHIEVEMENTS MADE

Several of the above phenomena are intimately related to the variation of intensity of illumination on Solar Cell particularly at high sunlight concentration, therefore, we have established a base line process for fabrication of concentration sunlight Silicon Solar Cell. Under these process the Solar Cells of 10% efficiency at 1 sun illumination and about 12% efficiency at 20 suns illumination have been developed.Process variation are now being study to further improve the efficiency of the Solar Cell.

To study the performance of these Solar Cells under prolonged concentrated sunlight, a Solar Cell panel of 50 of these solar cell in series combination has been fabricated. Some of the Solar Cells fabricated under our programme.

The developed concentrated sunlight silicon solar cells are generating short circuit currents of upto 6.8 Amp each and an open circuit voltage of 0.68 volts at sunlight concentration of 84 suns. The fill factor however is nearly 0.5 at these levels of illumination and efforts are being made to improve the same.

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# PHOTO-ELECTRO-CHEMICAL DIODES FOR SOLAR ENERGY

Suresh Chandra
Banaras Hindu University
Varanasi.

The need to harness solar energy hardly needs any justification. The present work has been undertaken to exploit a relatively recent strategy of solar energy conversion viz-"Photo-electrochemical solar cells (PESCs)" which utilise the photovoltic effects at the semiconductor/electrolyte interface. The following objectives have been set forth :-

(i) Analysis of the experimental and theoretical aspects involved in PESCs.

(ii) Development and optimisation of cheaper and simpler techniques for preparing semiconductor films with good crystallinity and uniform thickness over large area.

(iii) Fabrication, study of PESCs and optimisation of its performance.

(iv) Studies on the electrochemical aspects such as the search for suitable redox couples to prevent corrosion of photoelectrodes.

(v) To investigate the feasibility of a "built in storage mode" in PESCs.

Achievements:

(i) A critical assessment of the Material Science, Semiconductor Physics and electrochemical aspects of the problems has been carried out by us in the form of a review submitted for publication to Physica Status Solidi.

(ii) Simpler and cheaper chemical methods developed and optimised to prepare II-VI compound semiconductor films. The electrocodeposition method was used for growing CdSe and ZnSe Films while a chemical bath deposition method was adopted for CdS films. These films exhibited good crystallinity and uniform thickness over large area.

(iii) Structural investigation of the above films using electron microscope.

(iv) Assessment and optimisation of the performance of PESCs using the above films.

(v) Development of chemical methods for controlled doping of semiconductor films is also being carried out presently.

# Studies in Back Surface Field Silicon Solar Cells and Allied Devices.

S.K. Chattopadhyaya,
Kurukshetra University
Kurukshetra-132119.

Significant improvements have been made in Silicon Solar Cell performance during recent years mainly due to studies initiated at NASA, Lewis Research Centre, COMSAT Laboratories etc. One of the important achievements is the fabrication of Silicon Solar Cells having a 'back surface field' (BSF) with abnormally high open-circuit voltage and improved radiation resistance. The back surface field may be produced by a special alloying technique of a normal $n^+p$ junction or by the method of thermal diffusion, resulting in a $n^+pp^+$ structure. The high-low junction at the back of the normal $n^+p$ structure is found to be responsible for high open-circuit voltage and short-circuit current and also slightly better temperature dependence. The objective of the present scheme is to study the role played by high low junction at the back of the conventional Silicon Solar Cell fabricated under different conditions. Attempts will be made to characterize these cells by suitable parameter measurements.

During the last few years the investigator was engaged in the analysis of the performance of a diffused Silicon pn-junction photovoltaic device including the role of high-low junction. The results indicate that the role of impurity profile of the front diffused region as well as high-low junction at the back have significant role in the the determination of open circuit photo voltage as well as short circuit current of these cells. Moreover, since the back surface of a BSF cell is heavily doped, one should take into consideration the heavy doping effect in semiconductors while characterizing such cells., e.g., broadening of impurity states into impurity bands which ultimately result in an effective shrinkage of the forbidden gap of the material.

In view of the above, attempts have been made by the investigator to set up facilities for the measurements of various parameter of Silicon Solar Cells namely open-circuit photo voltage as a function of temperature, series resistance by variable illumination method, measurement of lifetime by open-circuit photo voltage decay etc. Presently an attempt is being made to set up experimental facilities for Anodic oxidation method for studying impurity profile of semiconductor devices by successive etching.

# PERFORMANCE OF HEAVILY DOPED SOLAR CELLS

M.S. Sodha and S.K.Sharma
IIT, New Delhi

We have for the first time derived an explicit expression for the photo e.m.f. developed across a degenerate p-n junction by using the general diffusion mobility relation which is valid even for the degenerate materials. We assume that while the acceptor concentration varies as the complimentary error function with the depth of solar cell, the donor concentration is constant throughout. We then solve the continuity equation in the presence of external radiation using the appropriate boundary conditions, for both kinds of carriers, to obtain the expressions for the excess charge carriers generated by the radiation. The knowledge of variation of excess carrier concentration as a function of depth of solar cell can be used to calculate the photo e.m.f. developed across a degenerate p-n junction.

We have also calculated the efficiency of Au-GaAs Schottky Barrier solar cells for AMO and AM1 conditions of sunlight for various values of temperature and photon number density by taking account the effect of excess temperature. It is seen from our calculations that the conversion efficiency of Au-GaAs schottky Barrier solar cell decreases by taking into account the excess temperature effect.

# TEMPORAL RESPONSE OF SOLAR CELLS

V.K. Tewary, BITS, Pilani

The aim of the project is to study various aspects of temporal response of solar cells for the purpose of developing testing methods for solar cells. During the aforementioned period the following two investigations have been carried out.

1. Modified surface boundery condition for solar cells:

A modified surface boundary condition for solar cells has been derived to account for the surface generation of carriers. Further work is planned to study its effect on the temporal response of solar cells.

2. Open Circuit Voltage Decay (OCVD) in p-n diodes:

In the conventional analysis of OCVD method for the determination of excess carrier life time in the base region of a Solar Cell/diode the effect of the diffused region is neglected. We find that even if the effect of diffused region isneglected in steady state, its effect in the transient state can be quite significant. We also find, however that even in the steady state the p-n coupling may be significant. A detailed analysis of the OCVD of diodes shows the following features:

(i) the p-n coupling results into an initial quick drop of voltage which is similar to the drop due to series resistance.

(ii) the effective decay rate is a combination of carrier life times in the base as well as diffused region.

(iii) the decay is described by a combination of error functions rather than the usually attempted exponential junction.

(iv) the decay is more linear when plotted against the square root of time rather than linear in time.

# Studies on Polycrystalline Cds Solar Cells

Hiranmoy Saha, Kalyani University

Ceramic Cadmium Sulphide Solar Cells have been fabricated from CdS powder by pressing, sintering and dipping techniques. The back contact is obtsined by electroplating of Indium and the forward contact by springloading goldplated electroformed coppergrid. The conversion efficiency of these cells be in the ranges of 4%.

The properties of the copper sulphide barrier layer have been investigated in some depth employing precision chemical methods. The thickness of Copper Sulphide layer has been determined to be in the range of 0.1 -0.3 microns by spectrophotometric analysis. The variation of its thickness with the time of dipping during the process of dipping has been determined. It is confirmed that the thickness of the copper sulphide layer for the ceramic Cds grows linearly with the square root of time.

The growth of the copper sulphide layer is further observed to be related to the activity of $Cu^{+}$ ions in the dipping solution which has been measured by a potentiometric arrangement of $Cu/Cucl_2$-$Kcl/Hgcl_2/Hg$ Cell. The range of the activity of cu $Cu^{+}$ ions that is to be maintained in the dipping solution for high efficiency cells has been identified as $2\text{-}6X10^{-7}$.

Further the stoichiometry of the $Cu_xS$ layer has been determined by spectrophotometric estimation of $Cu^{+}$ using bethocuproine and $S^{2}$ ion using chloranilate complexing reagents. The cells are observed to have a $Cu_xS$ layer with x lying dose to 2.0.

One of the major problems associated with Cds solar cells, is its rather rapid degradation in performance with time. Apart from the degradation associated with chemical oxidation of $Cu_xS$ layer by the oxygen in the atmosphere, the ceramic cells are observed to decay even when kept in an inert atmosphere a in vacuum. This degradation in both short-circuit current and open-circuit voltage of a ceramic Cds

solar cell has been sought to be explained through the grain-boundary diffusion of copper resulting into depletion of copper from $Cu_2S$ layer. An in depth study of grain boundary diffusion in Cds Solar C on the basis of surface accumulation method has been developed. The effect of a suitable built-in field through the incorporation of donor dopants like indium has been studied both theoretically and experimentally. It is observed that the rate of degradation of ceramic CdS solar cells can be effectively reduced by incorporating a suitable concentration gradient of Indium along the CdS layer leading to a built in field opposing the diffusion of $Cu^+$ ions through CdS grain boundaries.

The Mechanisms of grain-boundary diffusion in Cds Solar Cells are being further investigated at elevated temperatures.

The results of these investigation have been accepted for presentation in the National Solar Energy Convention, 1979, Bombay.

## Study of the stability of the Solar-Pond System.

P. Krishna, BHU, Varanasi.

One of the major problem concerning the utilization of solar energy is related to the ability to store the collected solar energy over a long period of time and ensure a steady supply of the same from the store. A reltively simple and inexpensive method of doing this is provided by the concept of a solar pond. In a shallow pond of clear water incident solar energy is primarily absorbed on the bottom surface of the pond, which then heats the layer of water at the bottom and causes it to rise setting up convection currents which distribute the heat to the rest of water. If by some means the convection currents could be prevented, the bottom layer would get hot and store the solar energy without appreciable dessipation. Indeed the upper layer of water being bad conductor of heat would effectively minimise heat loss by radiation from the surface. This can be achieved by having a salt solution in which a concentration gradient is maintained in such a manner that the density of solution is uniform throughout the pond inspite of a temperature gradient from the bottom upwards. Such a uniform density pond can be maintained by the addition of concentrated salt solution at the bottom at a controlled rate. Temperatures of upto 90°C for the bottom have been reported in literature by earlier workers [1,2].

The stability of such a solar pond system when thermal energy is withdrawn from the bottom layer for various purposes such as heating of homes, supply of hot water etc. is a complicated problem which has not been fully resolved and needs to be investigated in depth. In the present study it is proposed to construct a solar pond on a laboratory scale and determine the optimum conditions under which it can operate with satisfactory stability providing a contineous source of hot water without appreciable dessipation of solar energy. Once this is satisfactorily achieved in the laboratory it is proposed to try out the system on a more extensive scale by building a solar pond on the roof of our physics department building with a view to provide hot water for our needs. A schematic plan(figl) of the laboratory model will employ aninfra-red lamp as a laboratory substitute for the sun.

It is evident that the successful completion of such a project can have a great impact on the energy needs of our country where solar energy is plentiful. An expensive, sofisticated technology involving solar cells can only be used in a few centres near big cities. The solar pond system when developed promises an inexpensive artifes for the collection of solar energy which can be utilized all over the country including the rural areas. Hence this proposal.

## Study of Solid Electrolytes and Development of Solid State Batteries.

D.N. Bose, IIT, Kharagpur

The aim of this project will be to -i) prepare polycrystalline lithium based electrolytes such as $LiI(Al_2O_3)$, $LiSO_4$-$Na_2SO_4$ etc. and study their X-ray structure and ionic conductivity. The effect of doping and quenching with a view to increase the ionic conductivity and decrease the $\alpha$-$\beta$ transition temperature is to be studied in detail. Electrolytes are to be prepared by compression in a steel die at varying temperatures.

ii) Prepare and study the electrode properties of layer type transition metal chalcogenides of composition $MX_2$ or $MX_3$ where M = Ti, Nb, Ta etc. and X =S, Se or Te. These structures can incorporate significant amounts of an intercalate like Li and Na with no significant change in the host structure and hence can be used as cathodes in rechargable solid-state batteries. Thin film cathodes will be prepared by reaction of S and Se with metal foils and also composite cathode using a binder such as polyethylene tefion or graphite will be used.

iii) Finally Li/Li electrolyte/$MX_2$($MX_3$) type solid state batteries are to be fabricated and their discharge characteristics will be studied as function of electrolyte and electrode composition and structure, temperature and discharge current. It may be mentioned that promising results have recently, been obtained with $Li/TiS_2$ and $Li/NoSe_3$ systems which have energy densities of 450-480 WH/Kg compared with 247 WH/Kg of conventional $pb/pbO_2$ batteries. Other systems such as $Li/LiS_3$ are predicted to have energy densities as high as 970 WH/Kg and hence will affected considerable reduction in weight. Emphasis will be placed on the preparation and use of polycrystalline materials since these are likely to be used in actual cells. The use of materials such as lithium based system is envisaged because of the relatively low cost compared with silver based batteries and also because of higher energy density may be obtained at room temperature operation.

## Investigation of more efficient Photogalvanic Cells

V.R. Krishman, S.V. University College of Science
Tirupati.

Photochemical reductions of aromatic ketones in solution have been the subject of many investigations since the original discovery by Cianician and Silber in 1900. Irradiation of benzophenone in thoroughly, deoxygenated hydrogen donor solvents, such as isopropyl alcohol, gives a quantitative yield of benzo-pinacol and acetone. The quantum yield of benzophenone dis-appearance depends on the solvent, intensity of light absorbed etc. Intermolecular photoreduction of cyclic ketones has not been systematically, investigated, but it is believed that in hydrocarbon or aqueous solutions the reaction between the photoexcited cyclic ketone and the solvent becomes important.

Many of the organic dyes have also been reported to be reduced or oxidised by inorganic redox couples on being illuminated. A model system is shown below:

Solution : $A + Z \rightleftarrows B + Y$

Photochemistry : $A + Z \xrightarrow{h\nu} B + Y$

Electrodes : $A + e \rightleftharpoons B$
$Y + e \rightleftharpoons Z$

(A = Organic dye, B = Product, Y,Z = Redox couple)

It is felt that more power can be obtained with this system in a photogalvanic cell if electrodes with very different electrode kinetics are used.

We are at present carrying out the photochemical reduction of benzyphenone in different solvents.

# Investigations of Interstellar Molecules

S. N. Ghosh
Calcutta University, Calcuttta

The investigation of interstellar atoms and molecules is at present primarily empirical. Both physics and chemistry of these particles are not known. Lack of knowledge in these fields can be traced to the peculiar conditions of interstellar space to which these molecules are subjected-very low density, relativity large ratiation field and very low temperature. Yet these molecules present exciting problems and knowledge to astrophysics and cosmology. For example, the molecular formation in the interstellar space may provide an evolutionary sequence for interstellar clouds. Also, they are of considerable interest to space communication engineers and of concern to bioscientists.

Before World War II CN, CH and $CH^+$ were detected in the interstellar space as narrow lines in small clouds having 10-100 atoms per $cm^3$. Their absorption lines were observed in the spectra of stars. Afterwards a large number of molecules were detected in the interstellar space of which the most abundant one is $H_2$. This molecule was detected by observing its absorption line at 1100 Å with ultraviolet spectrometers carried aboard rockets and satellites. Complex molecules which are located in the dense regions of interstellar clouds were detected by microwave and millimeterwave spectrometers using ground based radio telescopes. Using these instruments until now more than 90 atoms, molecules, radicals and ions formed from 16 elements (H, He, C, N., O, Mg, Al, Si, S, Fe, Na, P, Cl, K, Ca and Mn) were detected in the interstellar space.

Formation and destruction processes of interstellar molecules are of great importance. For methylamine, due to very low gas kinetic temperature of dark clouds and its high adsorption energy ($> 3$ ev) the possibility of its formation by grain surface reaction mechanism is improbable. Again, since the rate coefficient for three body gas phase reaction is very low, its formation by this process is also not possible. The formation by ion-neutral gas phase reactions has been proposed and the calculated abundance is then compared with the observed value, Formation and destruction of certain other molecules e.g., formic acid, thioformaldehyde in the interstellar space are also considered.

# Splat Quenched vs. Vapor Deposited Amorphous Materials - Preparation and Characterization

V.D. Vankar
Indian Institute of Technology, Delhi

A Splat quenching gun has been fabricated which can be operated in vacuum $\sim 10^{-5}$ Torr. A quenching rate of $\sim 10^{8}$ oK/Sec has been obtained in pure lead. Several materials like Pb.Sb. Ge and their alloys have been splat quenched using this apparatus. Since crystallization rate in liquid quenching is governed by bulk diffusion whereas in vapor quenching is governed by surface diffusion, a systematic comparison of vapor deposited and liquid quenched Pb,Sb metals has been carried out. New metastable structures and enhanced solid solutions in these system have been obtained. The stuructural, properties and their transformation behaviour have been investigated using Transmission Electron Microscopy, X-ray diffraction and Differential Thermal Analysis Techniques. In pure lead a metastable hcp phase (corresponding high pressure phase) has been obtained by splat quenching at room temperature but no such structure was observed on vapor quenching. In pure antimony various metastable structures such as simple cubic fcc, tetragonal, hcp and a new rhombhohedral have been observed. However, by vapor quenching at room temperature only fcc and new rhombhohedral phases were observed but at liquid air an amorphous phase is also observed. The stabilization and transformation behaviour of these phases have been investigated.

Germanium is known to show amorphous structure on vapor deposition at room temperature. By adding elements like lead in Germanium it has been found that the amorphous phase is retained upto 7.5 a/o Pb by vapor deposition. However in splat quenching no amorphous phase was observed. On the other hand in lead rich composition the solubility of Ge enhances to 13 a/o by splat quenching and $\sim$ 5 a/o by vapor quenching. The stability transformation behaviour and their kinetics is further being investigated.

Further another system viz silver antimony alloy has also been studied by splat quenching with the aim of producing amorphous foils. Very thin regions of these foils showed amorphous structure in the composition range 31 to 43 a/o Sb. However in thick regions it is found to crystallize into the known intermetallic compound $AgSb_3$. This system is further being studied.

For preparing films/foils of high temperatures melting materials like molybdemum, tantalum etc. an RF/DC magnetron sputtering system has been fabricated and is being operated successfully. The effect of various gaseous impurities on the stabilization of metastable phase in lead, antimony and lead Germanium alloys are being studied by the various techniques.

# CHEMISTRY

## CHEMISTRY

| | Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Design and fabrication of photo acoustic spectrometer. | Dr. P. Ganguly and Prof. C.N.R. Rao, IISc, Bangalore. |
| 2. | Solid state Chemistry of mixed metal oxide catalysts- Bismuth molybdate. | Prof. R.P. Rastogi, Gorakhpur University. |
| 3. | Relationships of Composition and Structure with the Electric and Magnetic properties of Spinel-like Ferrites. | Dr. H.V. Keer, IIT, Bombay. |
| 4. | Studies on the oxidation and dehydration of organic compounds on some prepared vanadates, polyvanadates vanadium pentoxide and activated Indian clay minerals. | Dr. K.P. Srivastava/ Dr. Rup Datta, BITS, Pilani. |
| 5. | Preparation and Characterisation of transition metal derivatives of group IV B elements catalysts. | Prof. R.N. Kapoor, Delhi University. |
| 6. | Structural studies of some bio-coordination compounds of phosphate and schiffbase groups containing co-enzymes- A Mechanistic study of Pyridoxal phosphate dependent enzymatic reactions. | Prof. C.C. Patel, IISc, Bangalore. |
| 7. | Photo-induced catalytic reactions on semiconductor oxides(chemical effects of light and storage of energy) modification of the oxide material. | Prof. J.C. Kuriacose, IIT, Madras. |
| 8. | Three dimensional X-ray diffraction and solid state studies on crystal structure determination of substances of organometallic, polypetides biologically active compounds and electronic materials. | Dr. P.C. Jain, Kurukshetra University. |

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| 1. | 2. | 3. |
|---|---|---|
| 9. | Search for new pesticidal mercury compound. | Dr. K.P. Dubey, University of Kashmir, Srinagar (J&K) |
| 10. | Flash Photolysis Study of Photo-chemical Reactions and Energy Transfer in Solutions and in micelles. | Prof. K.K. Rohatgi Mukherjee, Jadavpur University, Calcutta-32. |
| 11. | Studies on the Chemistry and Pharmacology of Heterocycles. | Dr.(Mrs) Julie Banerji, Univ. College of Science, Calcutta. |

# DESIGN AND FABRICATION OF A PHOTOACOUSTIC SPECTROMETER

P. Ganguly and C.N.R. Rao
Indian Institute of Science, Bangalore-12.

The aim of the project was to construct a spectrometer based on the Photoacoustic effect, in order to study crystalline and amorphous solids which are difficult to examine by conventional transmission spectroscopies. The photoacoustic effect is observed when monochromatic light chopped at accustic frequencies is absorbed by a sample. If the de-excitation occurs by a radiationless path there is a periodic heat flow to the surrounding gas. The resulting pressure fluctuation is picked up by a transducer (microphone).

A single-beam spectrometer has been fabricated to study the electronic spectra of solids in the UV/visible region. The most important part of the spectrometer is the sample cell. The cell used in the present studies (fig. 1) was a 7 cm diometer, solid aluminium block. The sample was mounted on a quartz rod and pushed in from one end and the microphone from the other. O ring seals were used to keep the cell air-tight. Light entered the cell from the side through two silica windows. A.G.R. 1/2 electret microphone was used in conjunction with a lock in amplifier. The reference signal was obtained from the chopper. The lock in amplifier output was recorded as a function of the wavelength.

A few, typical PAS spectra are shown in fig. 2(the spectra shown herein hav all been normalised with respect to the power spectrum of the source obtained using a black absorber). Fig. 2(a) is the spectra of poly crystalline $Cr_2O_3$. The spectra are comparable with those obtained with single crystal samples by conventional transmission methods and suggests the advantage of this method for the study of polycrystalline samples. The technique can be used to obtain the band gap/edge in amorphous and crystalline solids. Fig. 2 (b) show the band gap transition in amorphous and crystalline $As_2Se_3$. Fig.2(c) shown the PAS spectra of an intact leaf. All the features of chlorophyll are seen in the spectra. Thus the PAS technique could find profitable application for in-vivo studies of biological systems.

# Studies on solid state Chemistry of mixed metal Oxide Catalysts-Bismuth molybdate.

R.P. Rastogi and B.L.Dubey
University of Gorakhpur, Gorakhpur-273001

Objective of the work: Molybdates and tungstates have been used as catalysts in a variety of reactions of industrial importance. The selective oxidation of hydrocarbons with bismuth-molybdenum mixed oxide catalysts is of immense intersest since partially oxidised products are more useful than parent hydrocarbons. Depending upon the ratio of bismuth and modybdenum, there are different phases of bismuth-molybdate which are not equally selective. Since phase composition, magnetic and thermoelectrical properties, lattice constants and catalytic activity of a catalyst is affected to an appreciable extent by the mode of preparation, it is thought imperative to undertake a detailed investigation of solid state chemistry of bismuth-molybdenum mixed oxide catalysts.

Work done: The bismuth-molybdenum mixed oxides have been prepared in the solid state by calcining:-

(a) bismuth oxide and molybdenum trioxide in the molar ratios of 1:1, 1:2, 1:3, 2:1 and 3:1 and

(b) bismuth carbonate and ammonium molybdate in the molar ratios of 7:1, 7:2, 7:3, 14:1 and 21:1.

The different stoichiometric mixtures were homogenised in an agate mortar using acetone, dried and calcined at 580±10°C for 5 hr. It has been observed that carbonate and molybdate first decompose into their respective oxides which subsequently react to form bismuth molybdate (Fig.1). From TG and DTA experiments, it has been confirmed that neither the extent nor the rate of decomposition of carbonate and molybdate is affected in the mixed system (Fig. 1 & 2).

On varying the stoichiometric composition of the reaction mixture, the thermal behaviours of the reaction products have been found to vary. The calcination products of 1:2 and 1:3 molar mixture of bismuth oxide and molybdenum trioxide have been found to melt at 680 and 640 ± 10°C respectively, while those of 1:1, 2:1 and 3:1 do not melt (Fig.3). Similarly, the products obtained by calcining the bismuth carbonate and ammonium molybdate in the molar ratios of 7:2 and 7:3 show melting at the same temperatures where as 7:1, 14:1 and 21:1 do'nt melt.

## Relationships cfcomposition and structure with the elctric and Magretic properties of spinel-liek ferrites.

H.V. Keer.
Indian Institute of Technology, Bombay.

Recording tapes anddiscs use $\gamma$-$Fe_2O_3$ in the form of single domain particles having an acicular shape. This provides better alignment of particles and result in lower signal to noise ration on recording. $\gamma$-$Fe_2O_3$ has been prepared by various methods : the most common proceeds via the reaction route.

$$\alpha\text{-FeOOH} \xrightarrow{\text{dehydration}} \alpha\text{-}Fe_2O_3 \xrightarrow[\text{re}]{\text{reduction}} Fe_3O_4 \xrightarrow{\text{Ocidation}} \gamma\text{-}Fe_2O_3.$$

This was prepared by the thermal decomposition of ferrous oxalate dihydrate. The material thus obtained did not, however, have the required shape. The objective of the present studies is to prepare acicular $FeC_2O_4 \cdot 2H_2O$ and decompose it topotactically to give needle-shaped $\gamma$-$Fe_2O_3$. This enable formation of single domain particles having contribution from shape anisotropy. Acicular $FeC_2O_4 \cdot 2H_2O$ has been prepared by carrying out the precipitation in an aqueous medium containing glycerol. Considering the cost of glycerol, it was thought worthwhile to use a cheaper complexing medium for precipitation. A saturated solution of starch in water has been used and the oxalate formed is found to be acicular in shape, having a length to breadth ration of 8-10. This would be used as the starting material for the formation of $\gamma$-$Fe_2O_3$. Studies are in progress. Further, the above procedure would be extended to dope $\gamma$-$Fe_2O_3$ with small amounts of $Ni^{2+}$, $Mg^{2+}$, $Co^{2+}$ and some rare earch ions to study their effect on the structural, electrical and magnetic characteristics of $\gamma$-$Fe_2O_3$.

## Studies on the oxidation and dehydration of organic compounds on some prepared vanadates, polyvanadates, $V_2O_5$ and activated Indian clay minerals.

K.P. Srivastava and R. Dutta
Birla Institute of Technology & Science, Pilani.

In petrochemical industries phthalic anhydride finds wide utility in the manufacture of dyes, resins and plasticizers. Formerly it was being manufactured by catalytic oxidation of naphthalene but due to increasing demand of phthalic anhydride and scarce availability of naphthalene, the o-Xylene was searched as an alternative raw material.

Many processes developed, for the manufacture of phthalic anhydride by catalytic vapor phase oxidation of o-Xylene are covered by patents hence investigation was undertaken "to develope some suitable titania supported $V_2O_5$ mixed oxides, fused mixed oxides and vanadates catalysts for the oxidation of o-Xylene to phthalic anhydride".

Since o-Xylene oxidation is an exothermic reaction hence in order to maintain the reaction temperature within limit the oxidation was carried out in a "Condenser type fixed bed reactor" over silica, alumina and titania supported $V_2O_5$ catalysts and $TiO_2$ was found to be the best support for $V_2O_5$ catalyst for this reaction. $TiO_2$ supported $V_2O_5$ catalyst was further taken to increase its conversion efficiency by using it with different concentrations of $MoO_3$, $WO_3$, $UO_2$, $Co_3O_4$ and $CeO_2$ promoters and catalyst $TiO_2$:$V_2O_5$:$MoO_3$; 100:70:35.00 was found to give maximum conversion, 15.28% to phthalic anhydride with 82.41% selectivity. On studying these $TiO_2$ supported mixed oxides catalysts at temperatures 360°-580°C and space velocity 4000-7600 lit./hr./lit. their order of activities was found as follows:

$$V_2O_5/MoO_3 > V_2O_5/WO_3 > V_2O_2/CeO_2 > V_2O_5/Co_3O_4 > V_2O_5/UO_2.$$

When fused mixed oxides catalysts were tested then $MoO_3$: $V_2O_5$; 100:280 was found to have 19.40% conversion to phthalic anhydride with 82.16% selectivity. The activities of fused catalysts at temperature 360°-580°C and

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space velocity 8000-13000 lit./hr./lit. were observed in the following order:

$V_2O_5$-$MoO_3$ > $V_2O_5$(vanadyl oxalate)-$TiO_2$ > $V_2O_5$-$K_2O$($K_2S_2O_7$) > $V_2O_5$-$Co_3O_4$ > $V_2O_5$-$TiO_2$ > $V_2O_5$-Titania gel.

Among the different concentrations of Bismuth, Tin and lead vanadates supported on $TiO_2$ the $Pb(VO_3)_2$:$TiO_2$; 80% ; 20% catalyst gave maximum 15.21% conversion to phthalic anhydride with selectivity 77.83%. The activities of vanadates at temperature 360°-550°C and space velocity 3800-7800 lit./hr/lit. were observed as follows:-

Lead Vanadate > Tin Vanadate > Bismuth Vanadate.

Further studies are being carried out on above mentioned catalysts for the production of phthalic anhydride on a larger scale.

# Preparation and Characterisation of Transition Metal derivatives of group IV B elements and their applications as catalyst.

R.N. Kapoor
Delhi University, Delhi-7.

The precise objectives of this project were to prepare & characterize the complexes of group IV B elements. In this direction we have synthesized a number of titanium & zirconium complexes by the reactions of their alkoxides with aliphatic and aromatic hydroxy esters, carboxylic acid and hydroaxamic acids. A part from this a few organometallic derivatives of titanium & zirconium have also been prepared by the reactions of bis (cyclpentedienyl) titanium dichloride, mone (cyclopentadienyl) titanium trichloride, bis (cyclopentadienyl) zirconium dichloride with eximes, schiff bases, thioschiff bases, semicarbazone, hydrazones and certain other O,S,N containing ligands. The preparation of complexes of hafnium with thioschiff bases is in progress. The zirconyl complexes with macrocyclic ligands have been prepared and compared these complexes with those found in biological systems. The complexes of titanium & zirconium with esters are under testing to find out their activity while hydroxamates of titanium are of agricultrual interest. And we are in progress of establishing their activity in agricultural systems. The organometallic compounds of titanium has wide range of applications in the conversion of molecular nitrogen to ammonia. The preparation of the lower-valent compounds of titanium has also been carried out and successful results have been obtained in the preparation of Titanium (III) compounds.

Now we propose to carry out certain reactions to study the activity of titanium, zirconium and hafnium complexes as catalyst.

Structural Studies on some Biocoordination Compounds of Phosphate and Schiffbase Groups Containing Co Enzymes a Mechanistic Study of Pyridoxal Phosphate Dependent Enzymatic Reactions

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C.C. Patel
Indian Institute of Science, Bangalore

a. To synthesize schiff bases employing pyridoxal phosphates and related compounds and different aminoacids in the presence and absence of different metal ions.

b. To characterize the reactions and study their kinetics and mechanism.

c. To identify the structure of different schiff bases.

A literature survey on the subject has been done. This reveals that though a good amount of work has been done on different aspects of the above problem, a wide scope is available to further extend our knowledge about the system. Only a few structures of schiff bases formed from pyrodoxal phosphate have been solved so far by x-ray diffraction method. Growing of single crystal has to be standardized for x-ray single crystal work.

# Photoinduced catalytic reactions on semiconductor oxides( chemical effects of light and storage of energy) modification of the oxide material

J.C. Kuriacose
Indian Institute of Technology, Madras

The objective of this work is to examine the reactions of various substrates taking place on semiconductor oxide catalysts when subjected to irradiation that is absorbed by the oxides. With an understanding of such reactions it is intended to attempt setting up cells that could generate electricity when one of the electrodes is subject to irradiation.

Since many of these oxides absorb only in the ultraviolet region, they will be modified by suitabledoping/dye adsorption with the purpose of shifting the region of light absorption to the visible.

During the very short period since work on this project commenced, we have been able to set up photogalvanic cells using pure zinc oxide as well as zinc oxide on which some dyes are adsorbed, as the illuminated electrode. The cell liquid consists of a solution of potassium chloride with suitable alcohols, amines or amides added as reactants. The results indicate that various parameters like the intensity of light, the nature of the reactants introduced into the system, the shape and size of the electrode, temperature, etc. contrd the photovoltage that is generated.

A detailed study including an analysis of the products that are formed during the generation of the photovoltage is in progress.

# Three Dimensional X-ray diffraction and solid state studies on Crystal Structure determination of substances of organometallic, polypeptides, biologically active compounds and electronic materials.

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P.C. Jain
Kurukshetra University, Kurukshetra

In recent years structural investigation of compounds which are biologically active and which play important role in the human body have become important for crystallorgaphers. Similarly the detailed studies of the phenomenon of intergrowth, solid state properties, phase transition and semiconducting materials have gained prominence in the recent times for structural investigation.

In view of these importance, the crystal and molecular structure determination of some compounds have been undertaken under this scheme to get information and the specific properties of such active compounds. The compounds whose studies is in progress are: 2,6-dimethyl-1-thio-$\gamma$-pyrone and 2-(3', 5'-dimethyl-1-pyrazolyl benzothiazole). Both of them have low molecular weight and are biologically active. We have been particular in selecting small molecules because they can easily be studied by photographic technique of X-ray diffraction that is available in our laboratory. Their structural results will throw light on their behaviour that governs their properties and nature. It will also enable us to know the changes taking place in the lattice due to the changes in conditions.

Due to several limitations such as the funds for computer work and lack of the modern technique of Automated-diffractometer for X-ray diffraction intensity data collection, we have to go slow in our work. The efficiency of the work is further reduced in the absence of microdensitometer that is used for the measurements of diffraction intensity. Consequently, we have to determine intensity by visual method which is accurate upto 70% only.

We hope to get structural details on the above two compounds soon. But much will depend on how soon we would be able to get funds for the computational work on DEC-20 or DEC-10 computer.

## Search for new pesticidal mercury compounds

K. P. Dubey
University of Kashmir, Srinagar

Preparative and physico chemical studies on some potential pesticidal mercury compounds are being studied. In the past few years such studies on mercuric thiosalicylate and bisthiosalicylate mercurato (II) were conducted. Last year a thorough investigation of thioglycollat-HG(II) system was taken up. The pH and pCl measurements and gravimetric estimation of Hg(II) ions in the reaction mixtures containing different proportions of TGA and Hg(II) were conducted which established the formation of the compounds of the type Hg TGA and $[(Hg(TGA)_2]^{2-}$. The sodium and potassium salts of bisthioglycollato mercurate (II) were subsequently prepared and their composition established on the bais of analysis for Sulphur and Mercury in the compounds. The preparation of other heavy metal salts of bisthioglycollato mercurate (II), their characterisation and pesticidal activity are to be studied. Hg(II) compounds of some other sulphur/selenium containing ligands are also to be prepared characterised and their pesticidal activity determined.

# Flash photolysis study of photo-chemical reactions and energy transfer in solutions and in micelles

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Jadavpur University, Calcutta.

## Precise objective of the project

Redox reactions involving singlet oxygen is an area of research important in photobiology and atmospheric photochemistry. On the other hand redox reactions involving electron transfer in the excited states have created considerable interest in recent years partly due to the fact that the knowledge of excited state redox properties of various systems can help in the construction of suitable electrochemical devices for the utilization of solar energy. Such electron-transport systems play an important role in biological energy conversion as illustrated in the case of photosynthesis. It may be possible to organize a biomimetic electron-transport system as a first step in the construction of a man-made energy conversion device. These reactions can occur in homogeneous systems, in monolayers, in dye deposited on semiconductor electrodes and in micelles and vesicles.

In order to set up model systems to simulate biological electron-transfer processes, the excited singlet and triplet states of electron donor-acceptor complexes i.e. exciplexes constitute important category of systems to be studied. Such studies help in the understanding of relationship between photophysical and photochemical primary processes and molecular interactions. The electron transfer reactions are studied today in various fields of chemistry simplest of which is fluorescence quenching. However the fate of transient ion-pair produced by the electron transfer still remains unclear. It may dissociate into free ions, disappear by reverse electron transfer from the anion to the cation or convert into a new chemical species. Hydrated electrons can be generated photochemically and it may react with various molecules and radical cations present in the solution. Although reactions of hydrated electrons are very fast, $k = 10^{10}$ l $mol^{-1} s^{-1}$, under appropriate conditions the reaction rate can be controlled by the interface potential or the surface of the micelles and hence provide a convenient tool for the study of electron transfer reactions. With the development of polarographic pulse radiolysis technique it is possible to measure the redox potentials of such unstable systems. A systematic study of fast electron transfer

reactions can best be carried out by flash photolysis techniques. Ordinary flash lamps are useful for intermediates whose decay constants lie in the microseconds only. For nanosecond studies laser sources and fast oscilloscopes are essential.

The photosensitized oxidation of biological molecules *in vivo* is termed photodynamic action. The active species variously suggested is singlet oxygen $^1O_2$, or superoxide ion $O_2^-$. Such photodynamic effects can bring about genetic changes, hoemolysis of human erythrocytes (erythropoetic porphyria) and many changes in enzyme and membrane activities. Nature of the sensitizer plays an important role in such reactions.

Anthracene-1-sulphonate have been found to be a very efficient photodynamic agent since they can generate singlet oxygen efficiently. Some preliminary results on photosensitized oxidation of iodide ion has established that singlet oxygen is generated by energy transfer from sensitizer triplet state. These compounds can cause oxidation of proteins and nucleic acids also. Iodide ion is oxidised to $I_3^-$, presumably by electron transfer reactions. Antnracene sulphonates have also been found useful as fluorescent probes of polarity, for miceller interior and as indicator of phase transition temperature in membranes. Therefore, it is considered interesting to study photophysical and photochemical processes in these compounds. The nature of the triplet state can only be studied by flash photolysis techniques. The quenching of flurescence and phosphorescene by charged species like $I^-$ and $O_2^-$ may involve transient electron transfer mechanism. The photoreaction in miceller system will further help in the understanding of electron transfer reactions.

Some flash photolysis work carried out at the Royal Institution of Great Britain has given encouraging insight in the mechanism of photosensitized oxidation of iodide ion. Transients were observed one of which decayed in milisecond range and the other in microsecond range. The appearance of triplet-triplet absorption in presence of quencher like $I^-$ was a surprising result and needs further investigations.

A simple flash photolysis set up using photographic flash gun, a storage oscilloscope of 10 MHz time base and 50 watt tungsten-iodine lamp coupled with a grating monochromator as monitoring sources have been developed. The photographic flash gun puts a limit to the kinetic measurements only in the milisecond range. With this device ready

to use, initial studies will investigate the effect of various organic and inorganic quenchers on the decay constants of the excited singlet and triplet states of the sensitizer. The detection and estimation of short lived intermediates will help to establish a suitable mechanism for the photosensitized reaction. The laser photolysis available in Indian Association for Cultivation of Science can be used to study fluorescence quenching and electron transfer reactions of microsecond and nanosecond range (when fast oscilloscope is available). The effect of micellar environment on such processes, to simulate enzyme reactions, will also be studied. These studies will be coupled with the measurement of redox-potential of the excited states by photo-polarographic methods.

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# Studies on the Chemistry and Pharmacology of Heterocycles

Julie Banerji
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In continuation of our studies on the synthesis of indole compounds we have utilised the concept of annulation involving the electrophilic substitution of indoles. The primary objective of this investigation was to introduce C-3 and C-6 fragments at the 2- and 3-positions of the indole nucleus to enable us to use them as building units in constructing the macrocyclic rings. We report here the result of our investigation of the electrophilic substitution of indole with acetone in the presence of boron trifluoride. Three unusual heterocyclic systems were obtained, designated as dimers I, II and III involving the dimeric association of indole around four, three and three propenic units respectively. The structure of these products were settled from their spectral studies (including $^{13}$C-nmr) and transformation reactions. One of the products was characterised from its X-ray analysis using monoclinic crystals. The transformation product in chloroform of the third dimer, dimer III, has also been settled from X-ray crystallographic analysis.

Dimer II was found to be unstable when its chloroform solution was warmed and rapidly underwent dealkylation at C-3 to give a new product, dimer II a. This interesting change was studied using both H-1 and $^{13}$C-nmr spectroscopy.

The third compound, diver III, underwent rotational change in dimethyl sulphoxide, to a more stable form, dimer IIIa. This was necessary to alleviate overcrowding which probably arose due to hydrogen bonding of -CH and -NH functions with the solvent molecule. In chloroform the parent compound underwent an unusual cyclisation to a new product bearing an ether linkage and an oxindole chromophore.

# II

# BIOLOGICAL SCIENCES

1. BOTANY
2. ZOOLOGY
3. BIOCHEMISTRY
4. MEDICAL SCIENCES
5. AGRICULTURE

BOTANY

## BOTANY

| Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|
| 1. Inter-institutional Project on Hormonal control of Flowering & Fruiting including Forest Trees. | Coordinator<br>Prof. H.Y. Mohan Ram, University of Delhi.<br><br>Investigators:<br>Dr. H.P. Bhatnagar, Forest Res. Institute, Dehra Dun.<br><br>Dr. S.C.Bhargava/ Dr. S.K. Sinha, IARI, New Delhi-12. |
| 2. The limnobiotic studies and the utility of the thermal waters of Bhim-bundh, Monghyr, Bihar. | Prof.J.S. Datta Munshi, Bhagalpur. |

# Flower sex distribution, limitations to fruit set and enhancement of fruit set in some crop plants.

H. Y. Mohan Ram
Delhi University, Delhi

## Objective of the Project

To understand flowering behaviour, flower sex distribution and constraints to fruit set in cashew and to develop techniques for increasing production in cashew and nutmeg.

## Technical Programme

1. Identification of high yielding varieties, and determining the relations between flower number, flower sex, flower drop and fruit set per bunch and per tree in cashew. This will also cover studies concerning pollination biology.

2. Attempts will be made to enhance bisexual/female flowers where these limit fruit yields. The effect of exogenous application of gibberellins will be tried for inducing male flowers on genetically female plants of nutmeg with the intention of producing seeds that would bear truly female plants.

3. Spraying of flowering trees with certain mineral compounds and growth regulators to improve yield, especially by preventing fruit drop in cashew.

4. Basic studies to understand sex differentiation, and to determine methods of ascertaining the sex of seedlings using either purely biochemical or a combination of biochemical and morphological characters will be carried out. These would necessarily include determination of hormones, proteins, (isoenzymes) and levels of other metabolites during different growth stages. The aim will be to try to evolve a safe method of seedling sex prediction in nutmeg.

5. Tissue culture work will be taken up as a means of rapid multiplication of high yielding varieties. Mechanisms controlling the growth and differentiation of these plants *in vitro* will be elucidated.

6. Experiments will be conducted to understand the factors involved in juvenile flowering. The necessary biochemical and physiological studies will be carried out simultaneously.

# Hormonal Control of Flowering and Fruiting in Forest Trees

H.P. Bhatnagar
Forest Research Institute, Dehradun

## Objectives

To study the basic causes of inability of trees to flower in juvenile conditions, with special reference to the hormonal balance in the terminal meristems.

## Brief outline of the project

Forest trees in general take about 3-10 years before they produce first flowering. The causes of their remaining in juvenile phase for a longer period are practically unknown. The results will provide useful information about the factors both internal and environmental responsible for change from vegetative to reproductive phase. Based on the findings of this project, it will be possible to device techniques of initiating early and enhanced flowering in trees in seed orchards.

## Work Proposed to be carried out

(i) At the initial stages, photoperiodic requirements of the seedlings at different stages of development will be determined and this information used for giving hormonal treatments.

(ii) Treatments with gibberellins ($GA_3$, $GA_4$=7, $GA_7$) and auxins (IAA) will be given to the apical meristem in different ontogenic stages and observed for growth and phase changes.

(iii) The endogenous content of growth regulators, especially gibberellins and auxins will be estimated at different ontogenic stages and under different photoperiodic treatments.

(iv) Experiments will also be conducted to study the presence of some inhibitors/promoters and their relative ratios at different ontogenic stages and their role in flowering stimulus.

(v) The role of carbohydrates will be studied especially with respect to their synthesis in leaves, transportation and utilisation at the time of floral induction, to study the source/sink relationship.

(vi) Grafting experiments will be carried out using scion material from flowering branches on the saplings stages to stimulate evocation in the juvenile shoot apices. Also young or juvenile seedling material will be grafted on to mature plants which has reached flowering stage to see phase change can be induced in the juvenile seedlings. In these studies attempts will be made to study the qualitative and bio-chemical changes (if any) that occur during the process of evocation.

(vii) The qualitative as well as bio-chemical differences between juvenile and adult leaves (the organs which are responsible for production of floral stimulus for inhibitor) will be investigated.

# Flowering behaviour and flower shedding in pulses and oilseed crops

S.C.Bhargava & S.K.Sinha
Indian Agril. Research Institute, New Delhi.

Objectives of the Project:

Studies on flower bud and flower shedding in mung bean, cowpeas, arhar and sesamum has shown that the fruit setting ranges between 15 to 20 per cent in most cultivars. Among the various factors, the availability of photosynthites and nitrogen, hormonal imbalance, humidity and water stress are considered important. In pulses these conclusions were based on the demonstration of intraplant competion after flowering between the developing fruits and nodules. The excision of flowers resulted in prolonging the life of nodules. Since nodules and roots are known to supply nitrogenous compounds and cytokinin, the involvement of these could not be ruled out. Furthermore, water stress could accentuate the process of flower shedding.

In Sesamum, usually a single bud develops in each axil instead of three potential buds. When the central bud is removed, the lateral two potential buds develop. This is suggestive of hormonal involvement in flowering of potential buds in this plant. Furthermore there is a gradual decrease in seed and oil yield, among the groups of fruits obtained from lower nodes to upper nodes. This could be due to competition for carbohydrates or other requirements. Thus it points to the need for synchrony of flowering and some degree of fruit maturity without impairing oil quality and having little effect on oil and protein yield.

Plan of work:

Pulses: 1) The pattern of flower drop of different branches and in relation to environmental factors will be studied.

2) Experiments to enhance photosynthesis through enrichment by $CO_2$ will be devised and their effects will be studied on flower shedding.

3) Efforts will be made to distinguish the effects of soil and atmosphere drought of flower shedding.

Oilseed crops:

1) Assessment of fruit set and study of floral biology.

2) Influence of diverse environments and plant hormones on the onset of flowering, synchrony, fruit set and maturity.

3) Changes in the endogenous levels of hormones at different stages of plant growth.

4) Hormonal status of retained and shedded developing fruits.

5) Enrichment of $CO_2$ environment and its relationship with fruit shedding.

# The Limnobiotic Studies and the Utility of the Thermal Waters of Bhimbandh, Monghyr, Bihar

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Bhagalpur University, Bhagalpur

The thermal spring constitutes a high temperature simple aquatic ecosystem where the most important variable is the temperature which controls the distribution of biota, productivity, succession and growth. As solar energy transformations are responsible for running the biosystems, it seemed necessary to investigate the seasonal variations in primary productivity. Allochthonous input of organic matter in the form of litter fall maintained the eutrophic nature of the thermal stream.

The gases of thermal springs generally contain He, Ne, A (rare gases) along with $C\Phi_2$, $H_2S$, $CH_4$ etc. The rare gases may be used in tube light industry. Besides, the microbiological analysis of the thermal spring will help us to know the potability of spring water and can be used for table water industry. In the present age of energy crisis, interests are growing exploring the possibilities of geothermal energy on a commercial scale from the source of the thermal spring. Huge quantity of heat it lost (12, 186 K.Cal/day in travesing only 40 m distance from 63°C to 57.5°C) from the thermal springs, which should be converted into usable energy by some sort of thermocouple principle.

A preliminary survey of the thermal spring of Bhimbandh has been made since August, 1979. The temperature of the source of the spring remained almost constant at (61°C). The spring water is acidic, pH ranging from 5.5 to 6.5 along the temperature gradient of the hog stream. $CO_2$ occurred as free (1.5 to 16.5 $mg.l^{-1}$) and so carbonate alkalinity could not be detected. Bicarbonate alkalinity ranged between 18 and 20 $mg.l^{-1}$; chloride content was very low (4.5 to 5.0 $mg.l^{-1}$). Silica content varied between 50 and 75 $mg.l^{-1}$. The thermal spring of Bhimbandh appears to be of meteoric low salinity (silicious) type.

The source is characterised by the presence of a blue green alga, Synechococcus lividus only. Myxophyceae were only present at the higher range of temperature (50-61°C) while Bacillariophyceae and Chlorophyceae appeared in the lower range of temperature (50-46.5°C). A dytiscid beetle, Guignotus pradhani usually encountered below 45 °C. Besides, chironomous larva, a fish species Danio dangila was found below 40°C.

The primary productivity studies of phytoplankton and periphyton at 46.5°C showed greater gross primary production of periphyton (2.5 $g.c.m.^{-3}.hour^{-1}$) than phyto-plankton (0.624 $g.c.m.^{-3}.hour^{-1}$) The decomposition rate of litter fall along the thermal gradient is in progress.

# ZOOLOGY

## ZOOLOGY

| | Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Inter-institutional project on 'Manipulation of behaviour of insect pests for their control. | Coordinator<br><br>Prof. K.N. Saxena,<br>Delhi University.<br><br>Dr. S.S. Krishna,<br>Gorakhpur University. |
| 2. | Inter institutional project on 'Studies on the behaviour, reproductive physiology and endocrine regulation of reproduction of the avian pests of west Bengal. | Coordinator<br><br>Prof. Asok Ghosh,<br>Calcutta University.<br><br>Investigators:<br><br>D. Biswaranjan Maiti,<br>Calcutta University.<br><br>Dr. S.P. Bhattacharyya,<br>Kalyani University.<br><br>Dr. A.K. Sarkar,<br>Burdwan University.<br><br>Dr. B.C. Pal,<br>North Bengal University,<br>(West-Bengal) |
| 3. | Behavioural biology of hapalia Mechacralis and hyblaepuera (teak pests) | Dr. V.K.K. Prabhu,<br>University of Kerala,<br>Trivandrum(Kariavattom) |
| 4. | Cytogenetical Analysis and Experimental Hybridization in Freshwater Food Fishes. | Dr. K.K. Rishi,<br>Kurukshetra University. |
| 5. | Molecular Biology of the DNA-Loss in terminally differentiation lens fibre cells. | Dr. Sohan P. Modak,<br>University of Poona,<br>Pune-411007. |

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| 1. 2. | 3. |
|---|---|
| 6. Hypothalamic control of Reproduction in some Indian Fishes. | Dr. Shamim Haider, Surgical Res. Laboratory, BHU, Varanasi. |
| 7. Control of Annual Rhythms. | Dr. Asha Chandola, BHU, Varanasi. |
| 8. Studies on the Genetic Markers (Cytogenetical and Biochemical) in Cancer with reference to their Etiologic, Diagnostic, Prognostic and Therapeutic Value. | Dr. R.C. Sobti, Panjab University, Chandigarh. |
| 9. Role of hetero-chromatin in the evolution of the members of the nasuta subgroup of Drosophila. | Dr. H.A. Ranganath, University of Mysore, Mysore. |
| 10. Replicative Organisation of Drosophila Chromosomes. | Dr. S.C. Lakhotia, BHU, Varanasi. |

# Manipulation of behaviour of Insects Pests for their Control

K.N. Saxena
Delhi University, Delhi

The behaviour of phytophagous insects plays on important role in their establishmen on different crop plants and the damage caused to them. Hence, appropriate manipulation of the behaviour of insect pests can interfere with their establishment and thus help in their management/ control. For this purpose, it is necessary to have a knowledge of: (1) the types of behaviour of insect pests which are suitable for manipulation, (2) the factors which determine their behaviour, and (3) the modes of manipulating their behaviour for management/control.

The types of behaviour most appropriate for manipulation include orientation (attraction/repulsion), feeding, oviposition and mating. The factors determining these types of behaviour include various sensory stimuli viz., visual (colour, pattern), odour, humidity, taste, etc, and the insects' physiological as well environmental conditions. The modes of manipulating these factors and, thereby, the behavioural responses of different insect pests would very according to their biological characteristics. The factors governing the above mentioned behavioural responses and modes of manipulating them are being investigated in the present work with reference to different insect pests.

Orientation of the pests can be manipulated by attracting and trapping them at certain coloured paper patterns for manitoring or suppressing their populations.

Efforts to manipulate the ovipositional behaviour of the pests are aimed at:

(i) inhibiting oviposition on host plants and thereby suppressing the pests' population by certain sensory stimuli from (a) certain non-host plants which can be grown as inter-crops or (b) other sources viz., odours from certain armatic substances;

(ii) promoting oviposition on certain non-host plants which can be grown as intercrops and which would not support nutrition and growth of the insects, resulting in a decline in their population. Manipulation of the feeding behaviour involves inhibition of this response to host plants by certain chemical stimuli particularly odour which are to be preferred over contact antifeedants.

For manipulating their mating behaviour, efforts have been made to interrupt communication, courtship and, hence, mating between the sexes by certain sounds and odours.

# Manipulation of behaviour of insect pests for their control.

S.S Krishna

University of Gorakhpur, Gorakhpur

The objective of this research programme presently in operation at Gorakhpur University Centre as part of an inter-institutional investigative study in collaboration with Delhi University is primarily to collect detailed information to help in formulating guidelines for manipulating Earias fabia Stoll (a pest of cotton, okra and other malvaceous plants) so that applied biologists can work out practical control schedules in fields according to prevailing conditions.

Field and laboratory investigations clearly point towards the preference of E.fabia larvae for tender fruits of okra plant, especially those falling within the age group 0-5 days and containing within them soft, developing seeds for proper orientation and growth leading to the successful establishment of this pest. The caterpillars choice for such fruits has been correlated with water content and chemical constitution (water soluble proteins, carbohydrates and the presence or absence of certain components soluble in water, ethanol, chloroform or ether) of this plant part. The importance of okra seed nutrition, in terms of its temporally associated physiological necessity, in influencing development and reproduction of the spotted bollworm has also been appreciated.

Studies conducted to determine the impact of variation in sex ratio in the adult population on this insect's reproductive programming indicate that males in equal or in greater number per female promote egg output and release of fertile eggs in the female.

# Studies on the behaviour reprodutive physiology and endocrine regulation of reproduction of the avian pests of West Bengal

Asok Ghosh & BR Maiti, Calcutta University
SP Bhattacharyya, Kalyani University
AK Sarkar, Burdwan University

## Objectives of the project

Birds are considered to be pests which causes extensive damage in agriculture and pisciculture. In India according to the report of FAO (1967) about fifty percent of food grains are wasted by rats, birds and insects. Thus from economic point of view the importance of pest birds cannot be ignored (Murton and Wright, 1968). In India this problem has not been properly evaluated and measured regarding the control of the pest birds have not been received careful attention. Therefore to control the population of these deliterious birds one of the necessary pre-requisite is to know thoroughly the breeding biology as well as the general endocrinology of these birds. This project has immense economic implications from the stand point of agriculture in our country, because bird pests are decidedly been proved as menace to our agriculture.

## Detailed report

The present report comprises of selection of proper avian pests and standardization of some staining techniques and histochemical methods for future investigation.

We have selected 4 different types of pest birds on the basis of their food and feeding habit, the degree of damage caused, availability throughout the year and also the survivibility in laboratory conditions. After selection of the birds we are now studying the month-wise changes in the gonads and endocrine physiology of these birds taking histological and histochemical parameters in consideration.

## Calcutta University Centre

Several organs (testis, ovary, adrenal and thyroid) were employed and processed for routine microtomy.

Findings

1) Lonchura malabarica (White-throated munia)
Order - Passeriformes, Family - Ploceidae

The white throated munia is a non-migratory finch. It is a plain earthy brown, thick-billed bird with pointed black tail. The underpart of the body is white. There is no sexual dimorphism. It causes extensive damage of paddy, millet, dari etc.

The testis is in regressed condition and is invested by a thick connective tissue covering - the tunica albuginea. The seminiferous tubules are small, round and are separated from each other by large areas of interstitial tissues. The germinal epithelium consists of a single row of cells containing spermatogonia and Sertoli cells. The tubules are filled up with cholesterol positive lipid granules. Interstitium contains loose connective tissue with fibroblasts, blood vessels and cells of Leydig. The interstitial cells are very faintly positive to sudanophilic reaction.

The ovary is in inactive condition. The follicles of the ovary are too small to be observed macroscopically. Histological section shows many small primary follicles. They had a single layer of cells - the so called granulosa cell containing roundish nuclei. Beside these follicles a large number of developing follicles are present. The primary follicles are filled up with cholesterol positive lipid granules. The largest follicles have distended sudanophilic glandular cells in the theca interna. Fully differentiated follicles are not seen. Some old atretic follicles are present.

The adrenal gland is invested by a capsule consisting of dense connective tissue. The gland consists of two main types of tissues - the cortex and the medulla. The cortical and medullary tissues are intermingled throughout the gland, the cortical cords are occurring as irregular cords between which medullary cells interdigitate. The gland is highly vascularised.

Histochemical studies show that the adrenal gland is strongly positive to chromate-dichromate reaction but it is faintly reactive for iodate reaction which is specific for noradrenaline. This means that the reaction of chromate-dichromate is mainly due to adrenaline.

Microscopically, the thyroid gland consists of several follicles of variable size. The peripheral follicles are larger than central ones. The follicles are compact and lined by a single layer of columnar epithelium. Extensive vacular supply is provided to the follicles.

From the above study it is evident that the bird is not in breeding condition during this month. But it is not possible to comment whether it is in pre-breeding or post-breeding condition.

2) Dendrocitta vagaburda (Tree pie)
Order - Passeriformes, Family - Corvidae

It is a long tailed chestnut brown bird with sooty head and neck. The black-tipped grey tail and greyish white patches are conspicuous during flight. The bird has no sexual dimorphism. It causes damage of fruits.

Burdwan University Centre

Acridotheres tristis (Common myna)
Order- Passeriformes, Family - Sturnidae

It is a perky, well-groomed dark brown bird with bright yellow bill, legs and bare skin round eyes. A large white patch in wing is conspicuous during flight. Sexes are alike. It causes damage to fruits. Workers at the Burdwan University Centre have started working on the reproductive cycle of this species. It is too premature to comment on this investigation.

Kalyani University Centre

Detailed study of male reproductive organs and male reprodutive cycle in red-vented bulbul (Pycnonotus cafer Linn.) which appears to be one of the common bird pests in many regions of West Bengal. While selecting this species, availability of the specimen, its involvement in crop damage and its survival under laboratory conditions have been taken into consideration.

This study comprises : (a) detailed histological investigation of the testis, male genital duct and male accessory structures; (b) kinetic and quantitative study of spermatogenesis; (c) histochemical characterization of gonad and the genital duct; (d) determination of histochemical constituents of the testicular fluid and seminal plasma (e.g., lipids, cholesterol, glycogen, sialic acid, fructose, lactid/citric acid and activities of alkaline phosphatases, acid phosphatases, G-6-Pase etc.); (e) investigation of the histophysiological and biochemical constituents of the testis and male genital duct during different phases of reproductive cycle a month-wise scanning throughout the year.

The work under this scheme commenced from 16th November, 1979. At the outset, sometime has been devoted to standardize some important histochemical and biochemical procedures such as, methods for determination of glycogen, lipids, sialic acid, free amino acid and activities of enzymes as mentioned above, which are not only the main constituents of mammalian seminal plasma but also by enlarge are the important androgenic parameters. In the avian field information is rather meagre.

Besides, during this period histological study of testis and genital duct of P. cafer has been grossly studied. The testis show a stage of regression. This has been evident from small tubular diameter, absence of spermatozoa in the testis lumen and to a content of lipid and cholesterol in the irterstitium. The vas deferens also show a regression from histobgical point of view.

# Behavioural Biology of *Hapalia machaeralis* and *Hyblaea puera*, the teak pests

V.K.K. Prabhu
University of Kerala, Trivandrum

The project envisages to study the behavioural biology of the lepidopterous pests *Hapalia machaeralis* and *Hyblaea puera* infesting teak treas (foliage), in relation to feeding, reproduction and environment so as to collect information and draw conclusions which will be useful in controlling these pests causing heavy damage to teak plantations.

# Cytogenetical Analysis and Experimental Hybridization in Freshwater Food Fishes

K.K. Rishi
Kurukshetra University, Kurukshetra

This project was started in August, 1979. The main objectives of the project are- I. to analyse cytogenetically important freshwater food fishes by employing latest techniques, II. to attempt experimental hybridization in various species at intraspecific, inter-specific and intergeneric levels and to examine the hybrids cytogenetically, III. to determine the advantageous features, if any, of the hybrids, and IV. to suggest measures for the improvement of fish stocks.

Since the beginning of the research work, progress has been made in the procurement of the basic facilities and preliminary cytogenetical work on Labeo rohita, L. calbasu, Catla catla, Cirrhinus mrigala, Clarias batrachus, and Heteropneustes fossilis has been completed. Attempts are being made to develop techniques to obtain various types of banding in fish chromosomes for more precise analysis.

In the coming breeding season, experimental hybridization will be attempted in two catfishes, Clarias batrachus and Heteropneustes fossilis. These fishes are suitable to begin with since their handling presents less difficulty. Hybridization will be tried at intergeneric and intraspecific levels. An effort will be made to obtain homozygosity by inducing gynogenesis. If successful, these homozygous strains will then be crossed to obtain intra-specific hybrids. Work on the same lines will be done on other fishes also. Improvisation work on the storage cisterns and a small hatchery for the above experiments is in progress.

# Molecular biology of the DNA-loss in terminally differentiation lens fibre cells

S. P. Modak
University of Poona, Pune

## Precise objectives of the project

1. To isolate on large scale lens epithelium, peripheral fibres, middle fibres and central fibres from 19 day-old chick embryo lenses.

2. To isolate and purify nuclear DNA.

3. To digest DNA with restriction endonucleases and to compare the molecular weight distribution of restriction-fragments by gel electrophoresis.

4. To study the reassociation kineties of DNA for different cell population using hydroxyapatite chromatography and $S_1$ endonuclease sensitivity assays (partly).

## Summary of the work done

During the one year period, the following work has been carried out in fulfilment of the specific aims:

1. 1000 lenses from 19 day old chick embryos were dissected. Epithelial and fibre cell populations were separated and stored.

2. From 200 lense cell populations, DNA was extracted and electrophoresed in Agarose gels to study the molecular weight distribution.

3. From the 19 day chick embryos, liver and brain tissues were collected in order to prepare DNA as well as to locate at other biochemical parameters.

4. We have recently noticed that the cellular levels of polyamines is a good indicator of cellular metabolic activity with specific reference to proliferation, differentiation and neoplasia. With this in mind, we have developed a rapid and sensitive method to isolet, purify and quantify different polyamines. This method involves homogenesetion of tissues in 2% TCA followed by fractionation of the polyamines in the supernatant by passage on

Dowex-50 ion-exchange resin. The retained poluamines are eluted and electrophoresed on papers, revealed by Ninhydrine reagent made in cadmium acetate, eluted and estimated colorimetrically using appropriate calibration standards. This procedure allows a recovery of 90-95% of poluamines. We are now in the process of comparing polueminesleveis and ratios among different embryonic tissues with specific reference to the chick lense. We hope to extend this approach to the analysis of polyamines bound to chromatin in various lense cell populations, since these reflect the transcriptionally active and inactive state of chromatin.

5. As soon as we have collected sufficient amount of lense material the next step involving analysis of restriction fragments of DNA will be undertaken.

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# Hypothalamic control of Reproduction in some Indian fishes

Shamim Haider
Banaras Hindu University, Varanasi

Objectives:

In higher vertebrates reproduction is known to be controlled through the hypothalamo-hypophysial axis. Very little is known about the hypothalamic control of hypophysial activity in fishes. With the available background data it was proposed to locate the hypothalamic feedback sites of gonadal steroids after experimental manupulation of the gonads. This type of work may have a direct bearing on pisciculture as it may help induction of spawning by manupulating at the hypothalamic level.

Achievements:

As a initial step the hypothalamo-hypophysial neurosecretory complex was studied using histochemical and histological techniques. In situ preparations helped in the determination of the pathways of the complicated neurosecretory axons. Our experimental studies show that the neurosecretory axons have remarkable capacity to regenerate.

In higher animals an ependyma-hypothalamo-hypophysial pathway is also suggested for the neurochormones modulating the pituitary function. Hence the ependymal histochemistry and its morphological relationship to the neurosecretory centresis studied. We find that the basal processes of the ependymal tanycytes lining the third ventricle are in contact with the neurosecretory elements and blood vessels. Apically they secrete into the cerebrospinal fluid. They also exhibit histochemical changes under the experimental conditions. These data are processed in the form of the following papers:

1. An in situ study of the hypothalamo-Neurohypophysial complex of the freshwater teleost Ompok bimaculatus (Bloch) with a note on on the Tetrapodan features of its vascularization. J. Neural Trans. 45 239-251 (1979).
2. Regeneration of the neurosecretory tract in hypophysectomized catfish Ompok bimaculatus (Bloch)- An in situ study. Endokrinol, (In Press).
3. Post - hypophysectomy changes in the nucleus preopticus and adjacent ependyma in the freshwater catfish Ompok bimaculatus (Bloch). In Press.

A detailed study on the pituitary cell types is made with special reference to gonadotrophs. Our observations show that the gonadotrophs and thyrotrophs stain alike with all basic dyes. However, the former can be detected by their hyperactivity and numerical increase during the breeding season. In this fish apart from gonadotrophs and thyrotrophs, ACTH cells, lactotrophs, somatotrophs, MSH cells and PAS positive cells of unknown function are identified.

# Control of Annual Rhythms

Asha Chandola
Banaras Hindu University, Varanasi

A number of behaviral and physiological parameters amenable to measurement exhibt seasonal periodicity viz., locomoter activity reproduction, fattening and molting in birds. These rhythms may be controlled by variations in environmental (photoperiod e.g.) factors. There is evidence also for the involvement of an endogeneous "quasi-annual' or "Circannual rhythm" though there still exists a controversy regarding their nature. There have been suggestions that instead of being autonomous/self sustaining these circannual rhythms may result from an interaction between environmental seasonal variations and circadian rhythms. Actually almost all the data in support of circannual rhythms derives from strongly photo-sensitive species in which any endogenous contributions to the timing of cycles could be masked by the physiological responses evoked by direct effects of photoperiod. From our studies for the first time a model (Spotted munia, Lonchura punctulata) is available in which an autonomous annual biological clock has been unequivocally established, and in which the "entraining effects" of photoperiod can be clearly distinguished from its direct "driving effects". Distinct free running rhythms (3 years) in reproduction, fattening, feeding pattern with a periodicity of about 10 months have been demonstrated in the so called nonphotoperiodic Spotted munia in continuous illumination (24L/0D) and 12L/12D alike. Interestingly the reproductive cycle in 12L/12D and ambient conditions moved out of phase with the monsoon period. Obviously monsoon in this case was not able to synchronise the cycle. There is indication that the period between spring and autumnal equinoces (L/D ratio more than L) might serve to fix an otherwise oscillating circannual system in Spotted munia, thus permitting reproduction to coincide with the most proptitious time of the year for the upbringing of young ones.

# Studies on the Genetic Markers (Cytogenetical and Biochemical) in Cancer with reference to their Etiologic, Diagnostic, Prognostic and Therapeutic Value.

R.C. Sobti
Panjab University, Chandigarh

A search for specific diagnostic methods for the detection of cancer has received significant impetus after the detection of immuno suppressive protein, but the detection and management of malignancies has not yet been possible by a simple and specific test of a patients' blood. During the last one and half year, an attempt has been made to study the serum proteins and LDH pattern (both from serum and malignant tissue) of the cancerous patients. It has been seen that the protein and LDH patterns of tumour cell extracts and blood sera show alterations in case of cancer patients.

Statistical analysis has been done to find out the significance of these alterations in order to suggest a marker for the malignancies.

Z test has been applied to each of the variations of four regions one by one, showing, thereby, that the greater thickness of albumin band is a characteristic feature of malignant sera ($Z = -5.57$).

The test applied to transferrin region shows no significant values et all, whereas complete diffusion or diffusion with some discrimination in the band between transferrin and albumin is a characteristic feature of malignant sera. Z values being -5.45 and -5.45 respectively.

Complete diffusion in the bands of globulin region has been seen ($Z= 19.69$).

Binomial test has further been applied to find out the most characteristic feature out of the three observed.

The test suggests that the diffusion in the globulin region is the most suitable marker which can immediately suggest the presence of malignant growth.

The protein bands of the tumour cell extracts suggest no marker, as the Z values have never been observed to be significant.

Z values calculated for all the six types of variations observed in the five LDH isonezyme bands show great significance in case of diffused bands.

Significant Z values for diffused bands are:-

| | $C_1$ | $C_2$ |
|---|---|---|
| $LDH_2$ | -5.34 | -5.33 |
| $LDH_3$ | -3.23 | -4.59 |
| $LDH_4$ | -5.72 | -7.47 |

The above mentioned values clearly show that the sera as well as the tumour cell extracts have a tendency to loose their distinctness. Diffusion in $LDH_{2,3}$ and $_4$ is, thus, a distinct feature of malignant sera and the tumour cell extracts.

Degree of diffusion of all the five bands has been independently calculated by applying a binomial test. The values have been observed to be very significant in case of LDH $_{2,3 \& 4}$, suggesting, thereby, that diffusion of $LDH_{2,3 \& 4}$ can act as a marker for malignancies.

The conclusions drawn from the observed patterns of proteins and LDH have no doubt been analyzed statistically, but finer techniques of densitometry and two dimensional electrophoresis must be applied before giving any statements regarding their application in the diagnostic purposes and the work in the direction is in progress.

In addition cytogenetical studies on as many as 12 different types of tumours have also been made and certain non-random chromosomal alterations have been observed. Notable amongst these are the markers in the testicular tumours (Sobti, 1980).

An attempt has also been done a study the alterations in the tumour cells and bloos of cancer patients with the help of 42 seed extracts belonging to ten different families. The seed extracts have been made to react with the tumour cells and the erythrocytes of normal as well as cancerous cases. Saline test has been done for this purpose, whereas agar gel immuno-diffusion test has been performed to see the precipitating activity of all the seed extracts with the sera of normal subjects, cancerous patients and their tumour cell extracts.

Analysing the data with the help of statistical evaluations, it has been found that Pisum sativum, Glycine max, Phaseolus vulgaris var. French beans, Phaseolus vulgaris var Rajmas and Phaseolus lunatus, aggeutinate the normal and cancerous erythrocytes. The difference, however, lies in the increased agglutination in case of erythrocytes of cancer patients, suggesting, thereby, that the binding sites in these cases are not very well distributed throughout the memberane. Seed extracts of Chenopoedium murale has been observed to be a significant agglutinin for R.B.C.'s of cancer patients. The precipitating activity of cancerous sera with Albizzia procera indicates the presence of specific antibodies in t

# Replicative Organization of Drosophila Chromosomes

S.C. Lakhotia
Banaras Hindu University, Varanasi

The above research project was plan to understand the replicative organization of chromosomes in unineme, polyneme and polytene chromosomes seen in different cell types of Drosophila and the relationship of these phenomena to development and differentiation in general. The results of present studies have provided very interesting information on the autonomy of replication of different components of nuclear meterial in Drosophila.

A comparative study of the non-replicating alpha heterochromatin in polytene nuclei in salivary glands of 8 species of Drosophila has revealed that the amount, organization and the location of the non-replicating heterochromatin within the chromocentre varies within as well as between closely related species.

$^{3}$H-thymidine autoradiographic studies in polytene nuclei of D.nasuta have revealed that the reported under-replication of rDNA cistrons in polytene nuclei is brought about by a slower and autonomous replication cycles of the intra-nucleolar (rDNA) DNA is these cells.

In polytene nuclei of two distantly related species, D.kikkawai D.nasuta, it has been observed that a specific puff site initiates a polytene replication cycle and the same puff continues to replicate even in the late S-period. These observations are in striking contrast to the general sequence of polytene replication known in other species of Drosophila.

An in vitro culture system for maintaining salivary glands from late 3rd instar larvae of Drosophila for a few days has been developed. It is significant that under these in vitro conditions, the polytene replication in different nuclei continues as in in vivo conditions. Using this convenient system, studies are in progress to analyse in detail the various aspects of polytene replication which could not be studied otherwise.

Autoradiographic and fluorescence studies on the replicative organization of larval brain interphase and metaphase nuclei have suggested that in different brain cells, even though not polytenic, there is a significant increase in DNA content due to endoreduplication cycles. Interestingly, during these endoreduplication cycles, the hetero- and euchromatic regions of a given nucleus replicate in independent cycles. Besides, a conclusive evidence has been obtained, by using $^{3}$H-thymidine and /or 5-bromodeoxyuridine labelling, for the development of a polynemic organization in majority of the mitotically active larval brain cells.

Studies on the replicative organization in wing imaginal disk of D.nasuta larvae have shown that contrary to the usual belief that th larvel imaginal disk cells are diploid, these cells also undergo endoreduplication cycles and during these endoreduplication cycles, the heterocromatin regions remain underreplicated. Besides, preliminary evidence has been obtained for the development of polynemic chromosome organization in these cells also. Presently, we are standardizing the in vitro culture system for maintaining larval imaginal disks in an undifferentiated stage. This would permit a detailed analysis of the cell cycle and chromosome organization patterns in these cells which are on the verge of terminal differentiation.

We have also standardized the culture conditions for in vitro culture of embryonic cells of Drosophila. This would now permit a comparative study of the replicative organization in the undifferentiated embryonic cells and in various larval cell types which have attained varying level of differentiation and which have different fates during pupal metamorphosis.

# BIOCHEMISTRY

## BIOCHEMISTRY

| | Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Inter-institutional project on 'Cellular Organelles'. | Coordinator<br><br>Dr. T. Ramasarma, IISc, Bangalore.<br><br>Investigators<br><br>Dr. J. Jayaraman, Madurai University.<br><br>Dr. G.S. Singhal, JNU, New Delhi. |
| 2. | Biological studies on the neoplastic transformation of cells. | Dr. T.N. Chapekar, AIIMS, New Delhi. |
| 3. | Electrical Communications in the Cellular slime molds. | Dr. V. Nanjundiah, IISc, Bangalore. |
| 4. | The Application of Lanthanide ions as Probes of Molecular Structures and Inter-Molecular Interactions. | Dr. P. Balaram, IISc, Bangalore. |

## Cellular Organelles

T. Ramasarma
Indian Institute of Science, Bangalore.

The aim of the project is to study organelle interaction with specific reference to the biogenesis, function and turnover of the mitochondrion.

It has been found that in the mold Neurospora crassa, the biogenesis of the mitochondrion is regulated by heme, the prosthetic group of hemoproteins. Heme is synthesized in the mitochondrion and is required for the synthesis of protein on mitoribosomes. This has also been demonstrated specifically for the synthesis of the mitochondrial subunits of cytochrome oxidase. Heme synthesis is regulated by $\delta$-aminolaevulinate dehydratase, a cytosolic protein. The interaction between mitochondrial proteins of cytosolic and mitochondrial origin is under study.

The modulation of the respiratory function of the mitochondrion by extra mitochondrial membranes has been studied. Addition of lysosomerich fraction decreases respiration in mitochondria without affecting the cyanide-insensitive respiration. Vanadate stimulates NADH oxidase activity in microsomes and in mitochondrial outer membranes which is sensitive to $\alpha$-quenching agents. Vanadate-stimulated NADH oxidase activity of microsomes is inhibited in the presence of mitochondria.

Subtle biochemical events have been shown to lead to a loss of mitochondrial function before total degradation of the organelle takes place. Oxidative activity of hepatic mitochondrial isolated from starved rats (5 days) is half of that shown by the mitochondria isolated from control animals. Mitochondria from starved rats have lesser number of binding sites for cytochrome c. These sites are not saturated with the pigment even though there is no deficiency of cytochrome c in the tissue. Similarly, addition of lysosomes to mitochondria results in decreased respiratory activity and this can be overcome by the addition of cytochrome c. Studies are underway to examine whether the results obtained are due to a modification of cytochrome c induced by the stress conditions.

## Cellular Organelles

J.Jayaraman
Madurai Kamaraj University, Madurai.

The compositional and functional changes in mitochondria under conditions of stress and their physiological relevance are being investigated. In fish, salinity stress is easily imposed. Under these conditions, mitochondria of the muscle and gill tissues respond by altering their ion uptake and osmotic swelling-contraction properties. Composition also is altered. Evidence so far accumulated point to the organelle functioning as an intracellular iono-osmo regulator.

In yeast in another form of 'stress', namely glucose repression, existing mitochondria distintegrate and on removal of glucose, there is a reformation of mitochondria. The reassembly of the mitochondrial membrane system has been shown to follow a particular temporal sequence.

Since two genetic systems that of the nucleus and of mitochondria are involved, the nature of interconnection between the two systems is also being studied.

# Organelle Interaction in terms of Molecular Processes and Energy Transduction.

G. S. Singhal
Jawaharlal Nehru University, New Delhi.

Chloroplast and mitochondrial protein can be categorised into three broad categories: (i) Proteins, coded by nuclear DNA and this class possibly constitutes the majority of structural proteins of organelles; (ii) Proteins, coded by the organelle genome, and (iii) Proteins, for which the coding information is shared by organelle as well as nuclear genomes. The organelles, thus function in a coordinated fashion with respect to overall economy and integration of various cellular processes. The basic aim of the project was to investigate various functional and structural aspects of plant chbroplasts and mitochondria, with a view to derive some insight into their possible inter-relationships. The following progress has been made so far:

## 1. Chloroplast proteins:

(a) Chloroplast membrane proteins have been analysed using polycarylamide gel electrophores. The major polypeptides fall into 8 categories, with a molecular weight ranging from 18 to 68 K daltons. The structural and functional properties (pattern of polypeptides and $O_2$ uptake) of chloroplasts have also been investigated using proteotylic enzyme, and various cross-linking agents.

(b) The enzyme ribulose biphosphate carboxylase-oxygenase, which serves as an ideal model system to study the chloroplast and nuclear interaction, has been purified almost to homogenity using gel and ion exchange chromatography. The appearance of enzyme activity with relation to subunit synthesis during germination of Triticale seed is under active investigation.

## 2. Studies on Mitochondria:

(a) In order to investigate the dependence of nuclear system on the replicative mechinery of mitochondria, mitochondrial DNA replication has been studied in relation to nuclear cell cycle in germinating barley embryos. The mitochondrial DNA synthesis begins after onset of the first S-phase, however, most of the mt DNA is synthesized between 15 and 17 hrs. (S-phase is from 10 to 20 hrs). The *in vitro* results suggest that plant mitochondria possibly lack enzyme thymidine kinase.

(b) Protein synthesis by isolated plant mitochondria has been studied. The study using various inhibitors of protein synthesis indicates that synthesis specifically occurs on 70S ribosomes in isolated mitochondrial fraction. The kinetics shows that incorporation is linear upto 60 min then reaches a plateau.

The comprehensive picture of interaction will emerge only after conclusion all the studies described in the report.

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# Biological studies on the neoplastic transformation of cells

T. N. Chapekar
All-India Institute of Medical Sciences, New Delhi

Intrasplenic ovarian tumorigenegis is an experimental model system which has an advantage over the other systems that it does not require any treatment of extrinsic factor(s) for the development of tumor. The transformation of ovarian tissue therefore is in all probability due to changes within the body.

This system in Swiss strain of mouse was used to study the changes that must be occurring in vivo vis-a-vis ovarian tumorigenesis.

Since spleen has vascular connection only with liver the steroid hormones secreted by autologously transplanted ovary in spleen are degraded by enzymes in liver with the result that the hormones are not available in the main blood stream to control secretion of pitritary gonadotropins which possibly increase in level and exert a physiological stress on ovaries in the spleen.

The questions posed to elucidate the mechanism of tumorigenesis were a) which cell type(s) is/are involved in the transformation, (b) how long the t ransplant takes to develop into tumour (c) the level of pituitary gonadotropins in blood plasma and (d) possible presence of oncogenic viruses in the transplant. Experiments were planned also to find out whether the transformation can be prevented.

Seventy four Swiss females were used in the autologous transplantation of ovary in spleen. The experimental animals were sacrificed at specific intervals of time starting from 3rd day through 15 months of transplantation. Observations on sequential transplants showed that the ovaries developed tumours by third month of transplantation. Thecal cells appeared to be involved in tumori genesis. The thecal proliferation was evident from the third day of transplantation which became extensive by fourth week. The frank tumours were composed of mass of thecal cells with trabeculae and glandular tissue formed out of follicls. Cystic condition was a common phenomenon. Electron microscopic observations did not reveal significant changes in ultrastructure of the ovarion tumour cells.

Plasma levels of luteinizing hormone (LH) did not increase while those of follicle stimulating hormone (FSH) increased right from the third day of transplantation. The experiments are in progress to study direct effect of high doses of FSH on thecal cells in tissue culture. The levels of gonadotropins were determined by radio-immunoassay in collaboration with Dr.Mrs. Nandini Sheth of the Cancer Research Institute, Bombay.

Since pineal gland regulates pituitary gonadodotropin secretion effect of additional pineal glands was studied by intraocularly grafting one to three pineal glands in the mice receiving intrasplenic ovary. Ten animals were so grafted. The recepients sacrificed after 3-4 months of transplantation did not show development of ovarian tumours although there was thecal proliferation to some extent without disturbing normal follicular morphology.

The experiments are in progress to analyse further, the pineal principle that is responsible for the arrest of the transformation.

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# Electrical communication in the cellular slime molds

V. Nanjundiah
Indian Institute of Science, Bangalore.

This concerns a scheme of research work proposed to be carried out in collaboration with Prof.O.Siddiqi, TIFR, Bombay. Cellular Slime Molds are primitive soil microorganisms that make a transition from a free-living, amoeboid stage to a social stage during the course of their life-cycle. This transition is mediated by communication between cells taking the form of reiterated bursts of a chemical signal spontaneously released as well as relayed by single cells. In response to the signal, cells move towards one another and ultimately form an aggregate. Certain features of this communication system are reminiscent of a nerve network: (1) the fact that the signal probably has an all-or-none character, (2) spontaneous oscillations in signal intensity, and (3) the occurence of concurrent oscillations in the level of extra-cellular pH, suggesting a role of ion movements in signalling. The puupose of the present study is to (1) measure the resting membrane potential of single cells, and its dependence on the ionic environment, (2) quantitate the extent of ion fluxes in response to chemical stimulation, (3) look for action potentials, and (4) measure the extent of electrical coupling between cells in an aggregate. As part of this study it is also intended to make quantitative measurements on physical parameters of the cell membrane in relation to external chemical stimulation.

At present a junior research fellow has been employed to assist in the work, and the bulk of the necessary equipment is in the process of being ordered. Preliminary experimental results indicate that these cells do have a resting potential, of about -12 mV, and that this potential seems to be primarily due to potassium permeability.

# Lanthanide Ions as NMR Probes of the Structure of Biomolecules.

P. Balaram
Indian Institute of Science, Bangalore

Eu(III) and Gd(III) may be used as NMR chemical shift and relaxation probes of molecular structure in aqueous solutions of biologically important molecules. The use of these ions in determining the molecular conformation of pyridoxal phosphate and pyridoxamine phosphate is illustrated. 270 MHz $^{1}H$ NMR data is fitted using the McConnell-Robertson equation and a computer search of the various conformational possibilities. $^{13}C$ NMR and Gd (III) induced broadening are used to provide additional support for the proposed structures. Theoretical conformational analysis is used to further refine the structures determined by the lanthanide induced shift method.

MEDICAL SCIENCES

## MEDICAL SCIENCES

| Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|
| 1. Inter-institutional project on 'Growth Differentiation in Normal and Cancer Cells: | Coordinator<br><br>Dr. C.R. Krishna Murti,<br>ITRC, Lucknow.<br><br>Investigators:<br><br>Dr. S.S. Agarwal,<br>K.G.M.C. Lucknow.<br><br>Dr. M.K. Sahib,<br>CDRI, Lucknow.<br><br>Dr. G.P. Phondke,<br>BARC, Bombay.<br><br>Dr.(Miss) Kusum Joshi,<br>Medical College,<br>Rohtak.<br><br>Dr. A.N. Bhisay,<br>Cancer Res. Institute,<br>Bombay.<br><br>Dr.(Mrs) V. Kothekar,<br>AIIMS, New Delhi-16. |
| 2. Studies on Model systems of cell-cell and cell-lectin interaction. | Dr. A. Surolia,<br>IITM, Jadavpur,<br>Calcutta. |
| 3. Targeting of Liposomes to testes using sperm 'Specific' Anti-Lactate Dehydrogenese-X (Anti-LDH) | Dr. Ateeq Ahmad,<br>CDRI, Lucknow. |

# Molecular Events in Cell Differentiation

C.R. Krishna Murti
**Industrial Toxicology Research Centre, Lucknow**

Induction and repression of synthesis of selective gene products has proved a useful tool in investigating cellular differentiation. The present project is aimed at investigating certain aspects of erythrocyte, lymphocyte and hepatocyte differentiation.

During last year (1979-1980) work was carried out on the following lines:

Effect of elevated temperatures (simulating fever) on DNA replication in different sub-populations of lymphocytes was investigated. Phytohaemagglutinin induced DNA synthesis could be further potentiated by incubation of the cells at evevated temperatures in T-lymphocytes only; while the temperature effect could not be demonstrated in B-lymphocytes. In vitro production of antibody and interferon wasfound to be reduced at 40°C as compare to 37°C.

-foetoprotein (AFP) is an important oncofoetal antigen. A simple and rapid procedure was developed for purification of AFP of rat and human origin. Briefly, rat AFP was isolated by precipitating out serum specific proteins of rat aminotic fluid with rabbit - anti-rat - IgG at optimal proporation; excess IgG was removed and AFP purified to homogeneity by DEAE cellulose chromatography. The AFP was found to be homogenous by different criteria besides SDS polyacrylamide gel electrophoresis (PAGE). PAGE under non-denaturing conditions yielded two bands: slow and fast moving. Both the bands demonstrated specific oestradiol and oestrone binding. AFP was found to binding $^{3}$H-oestradiol with an Ka = $1.9 \times 10^{8}$ $M^{-1}$. The two variants of AFP could be isolated on preparative polyacrylamide gel slabs. Antibodies raised against AFP gave precipition line with slow as well as fast moving variant, giving line of identity (fusion). Antibodies raised against the specific slow moving variant also cross reacted with the fast moving one giving line of identify.

# Effect of heat on lymphocyte proliferation

S.S. Agarwal
K.G. Medical College, Lucknow

The response of peripheral blood mononuclear cells to mitogens is enhanced at elevated temperatures. This is taken to imply that fever may serve physiological role in protection against infection. However, in-vivo febrile reaction does not invariably enhance the immune response. To explore this discrepancy, the proliferative response of different subsets of lymphocytes to mitogens at 37°C & 40°C was tested. Interestingly, proliferation of T-lymphocytes in response to PHA and PWM was enhanced at 40°C compared to that at 37°C, while the response on non-T (B enriched) lymphocytes was unaffected. This correlated with lack of enhancement of in-vitro antibody production and interferon induction at 40°C.

# Studies on hepatocyte differentiation: An improved rapid procedure for isolation or rat alpha-foetoprotein

Maharaj K. Sahib
Central Drug Research Institute, Lucknow

A rapid procedure is described for the isolation of pure rat alpha-foetoprotein (AFP) from amniotic fluid, requiring no more than two steps. This involves removal of adult serum proteins present in the anniotic fluid by direct negative immunoabsorption with rabbit anti-Rat serum IgG at optimal pracipitation proportion followed by removal of excess of antibody using DEAE-cellulose chromatography so as to yield immunochemically & electrophoretically pure AFP. The purified protein had an association constant Ka = $1.9 \times 10^8$ $M^{-1}$ for $^3$H-estradiol with number of binding sites for the steroid approaching unity per mole of AFP.

Polyacrylamide gel electrophoresis resolved AFP into two variants with closer mobility. Both the variants could bind nearly equal amounts of $^3$H-estradiol which could be completely displaced by excess of estrone. The two variants of AFP are found to possess common antigenic determinant site and are immunologically cross reactive.

# THE ROLE OF CELL SURFACE IN GROWTH AND DIFFERENTIATION

G.P. Phondke
Bhabha Atomic Research Centre
Trombay, Bombay

Two lines of investigation were undertaken

i) Surface Properties of Mitogen Treated Lymphocytes

Cell electrophoretic studies on the interaction of mitogens with murine lymphocytes were carried out to understand the changes in the cell surface associated with antigen-driven lymphoproliferation. Concanavalin A (Con A) which is a T-lymphocyte specific mitogen was used.

Treatment of the normal spleen cells of AKR mice (NSL) with Con A under capping conditions yielded a biphasic profile of electrophoretic mobility (EPM). The mean EPM increased significantly at low concentrations of Con A (2.0 to 12.5 ug/ml per $5 \times 10^6$ cells/ml), remained at that value before decreasing to a value below that of untreated cells at higher ( 15.0 ug/ml) concentrations of Con A. These alterations were observed only under conditions that favoured ligand induced redistribution i.e. capping and endocytosis of its receptors. While the increase in EPM at low concentrations of Con A could be ascribed to capping and endocytosis only, the reduction at higher concentrations was attributable to post redistributional binding of the lectin. It was further observed that these modifications of cell surface were produced only in a sub-set of the T-lymphocytes. B cells remained unaffected.

The role of the cytoskeletal elements in the modulation of surface receptor mobility and hence changes in the surface change density was also examined by evaluating the effects of pre and/or post-treatment with colchicine or cytochalasin B on the EPM. These emphasised the role of microfilaments in this process and more importantly, indicated that capping primarily contributed to change in surface charge density. Subsequent endocytosis had no effect.

ii) Cytofluorometric Investigations on Chronic Myeloid Leukaamia

Cytofluorometric assays were used to investigate cytological parameters associated with development of chronic myeloid leukaemia (CML). The parameters studied included cellular contants of DNA, RNA and protein. In addition, some methods were developed to quantitate the total negative surface charge and specific surface determinants.

The profile of the cellular contant of DNA of leucocytes from blood or bonemarrow was studied by staining cells with DNA specific stain propidium iodide. The leucocytes in normal peripheral blood constituted a homogeneous population with over 98% the cells in $G_1$ phase only. In contrast, leucocytes from CML patients gave a fairly good indication of the proliferation induced by CML. The fraction of cells in $S + G_2 + M$ varied from 10 to 40% in most of the cases examined. A close correlation was obtained between the cycling fraction and percentages of myelocytes and promyelocytes (which were obtained from cytological studies carried out by the collaborating group of Dr.A.N. Bhisey of the Cancer Research Institute).

To study simulaneously the profiles of cellular contant of DNA as well as RNA the leucocytes were stained with the metachromatic dye acridine orange which differentially stains double stranded DNA and single stranded RNA. The staining pattern of leucocytes of CML patients indicated a significant fraction of cells with high mean fluorescence per cell in the red region. Treatment of stained cells with RNase showed that this fluorescence was due to cellular RNA. The results thus suggested that the higher cellular contant of RNA may perhaps be characteristic of the cycling fractions of myelocytes.

## A study of cellular proliferation and differentiation in dysplastic and neoplastic lesions of the human breast.

Kusum Joshi, Rohtak Medical College, Rohtak

1. To study the proliferation kinetics of:
   (a) Dysplastic lesions of breast
   (b) Benign mammary tumours
   (c) Mammary carcinoma
      i) tumour itself
      ii) apparently healthy mammary tissue surrounding the lesion.
      iii) metastatic deposits in lymph nodes.
      iv) metastatic deposits at other sites.
2. To study differentiation vis a vis proliferation in the above said categories of tissues.
3. To study the effect of chemotherapeutic agents on proliferation kinetics and differentiated functions of tumour cells.

# Studies on the cell surface and cell kinetics in myeloid leucocytes during differentation and leukomogenesis

A. N. Bhisey
Cancer Research Institute, Bombay

The objective of the project is to characterises the cell surface of primitive myeloid cells, the differentiating cells and terminally differentiated granulocytes in the bone marrow and in peripheral blood in chronic myeloid leukemia. It is proposed to use various lectin probe for these investigations. It was also proposed to study the cell kinetics of leukemic cells - blasts and maturing cells.

During the early part of this investigation a microtiter method of assessing lectin aggluniability of cells was standardised. The kinetics of agglutination as a function of lectin concentrations and time were determined using three lectins viz. concanavalin A (Con.A) Abrin and Wheat germ lectin (WGA). On the basis of these experiments, concentrations of 5-, 10-, 20- and 40- ug/ml and incubation period of 15 min. have been finalised for these assays. To confirm the specificities of the lectin induced agglutination, the haptenic sugar viz $\alpha$-methyl mannose, Galactose and n-acetyl glucosamine are used for Con. A, Abrin and WGA respectively. Uptill now, studies have been carried out on peripheral blood leucocytes from 13 CML patients. All the three lectins caused agglutination. The degree of agglutination differed in different lectins and was also concentration dependent. The different lectins did not show similarities in their ability to agglutinate. Total peripheral blood leucocytes were separated into mature and immature cells. in g cases. The mature cells showed lower degree of agglutination with Abrin and WGA. Such a difference was not seen in Con. A. The agglutinating ability of lectins was checked by studying their effect at low concent-rations with yosida sarcoma cells.

Separation of cell types: Earlier attempts were made to separate various immature cells such as blasts, promyelocytes myelocytes and granulocytes on leucopac nylon column. These did not yield good results. Experiments are now in progress to separate the cells on Percoll gradients. Both bone marrow and peripheral blood cells from CML patients are being uced. In both cases, the cells are found to separate into three bands each consisting of (1) lymphocytes (2) immature cells (3) mature granulocytes, monocytes. The position of bands from bone marrow cells is slightly different from that for peripheral blood cells. The technique will be further refined.

Preparation of antibodies against actin and tabulin: Purified rabbit actin and pig brain tubulin were injected in rabbits. Actin was injected repeatedly and antisera were raised. An affinity column of actin conjugated to sepharose has been prepared and the antisera passed over it. The antibodies eluted from these are being tested for their specificity towards actin.

Studies on locomotion of CML leucocytes: Time lapse cinematographic studies were carried out on peripheral blood leucocytes from CML patients. The cells exhibit different patterns of locomotion which are being analysed.

Studies on the kinetics of leumic cells: Cytofluorometric studies on the DNA content were carried out on leukemic cells using propidium iodide as a fluorescent probe. These studies were carried out at BARC using an impulse photometer. A very large number of cells can be scanned by this technique. In CML, a large number of immature cells are released in the peripheral blood. It is not known whether these cells are in cell cycle or out of cycle i.e. in Go. Moreover the kinetics of the bone marrow cells is also not fully understood. Thus, there are potentially two separate compartments capable of contributing to the progression of disease. It is important to understand their potential to cycle for understanding the progression of the disease and for evaluating therapy. Studies were carried out initially on peripheral blood leucocytes in 20 patients. These showed a proliferating fraction varying between 10-40%. There was a parallelism between the total number of immature cells in the peripheral blood. A further study of both bone marrow and peripheral blood has been carried out in 15 patients and the data is being analysed. Using Acridine orange as a differential fluoreschrome for staining DNA and RNA, the human leukemic cells have been found to have a large fraction of cells showing red fluorescence which is sensitive to ribonuclease. This was not observed in normal leucocytes. Experiments are being carried out to study the nature and significance of this RNA.

# Pathogenesis of Cancer - Biophysical Study in Mechanism of DNA unwinding. Drug DNA and Metal DNA interactions

Mrs. V. Kothekar
All India Institute of Medical Sciences, New Delhi

The conformational and structural variation of DNA during its interaction with various carcinogenic agents, anticancer drugs, dyes and metals is known to play a significant role in Pathogenesis and therapy of cancer. It is quite difficult to imagine how a 20A° thick DNA molecule having a fragmental length of 650 to 700 A° can be packed into a small spherical Beads of 100 to 130 A° diam. nucleosomes and still interact with various drugs, proteins, dyes, metals. Various models have emmerged during past five six year for its explairation and recognition by DNA binding proteins like DNA polymerase, gene-5 protein of bacteriophage. Thus for example the Crick, Klug, Sobell, proposed a kinked DNA or packing with sharp turns, where the base stacking interactions are destroyed. Whereas Kornberg, Van Holde, Baldin, Weintrab, have tried to develope the old concept of packing round a protein core around successive histone octamers. The helical axis is constrained in the latter case and only the bases are pulled aside between 3.4A° to 6.8A° to accommodate the drugs. In case of proflaviour the planer chramophore could be inserted between adjacent base pairs in this model. Various models have also been proposed for interaction with metal ions, where the helical axis is still mentained in its position.

In both these cases there is always change of torsional angles of the nucleotide units. There may be alteration of the sugar pucker as well. This will lead to the change of conformational energy of the nuclectides. The long range interaction between the nucleotides and the drugs will ultimately decide the suitablity of a particular model over the other.

The aim of the Present work consists of studying the stereochemical and energetic aspects of DNA deformations and (2) analysing the interaction energy between DNA and drugs or metals The geometry of the molecule will be first computer simulated from internal coordinates of B-DNA allowing only variation of some torsional angles. Use will be made here of molecular modelling technique to predict the torsional angles. Such techniques was found to be extremely useful by us in the study of recombination DNA (14) and interaction of $Ca^{++}$ ions with prostaglandins.

The conformation energy of the deformed molecule will be then calculated on the basis of usual empirical potential methods. Use will be made of differnt molecular orbital methods when possible. The interaction with various drugs of metals will be then studies using empirical formulation of long range interactions of macromolecules developed by Claverie and Rein and longitudinal and transverse polarizability data by Le Fevre.

We have already dore a good deal of literature survey and developed computer program for the generation of DNA geometry as being composed of 'bricks' of nuclectides. The type of nuclectide can be altered by changing the 'brick' number and any 'brick' can be placed over any desired brick. The torisional angles of the nuclectide can be changed seperattely and the geometry can be regenerated. The obtained geometry can be tested for various geometric constrains. The second strand can be generated by incorporating proper symmetry elements. This programme does not involve much of computer memory as at a time we need only two 'Bricks'. This part of work can be done on any medium size computer. We have also made ready a geometry programme and graphic display program which can test various geometries.

Another set of programms is developed for the study of interaction between DNA and drugs or dyes using recent formalism by Calillet & Claverie. This is based on Summation over atom by atom which is quite fast as it avoids complicated mathematical procedures involving calculations with polarizability tensors.

Thus procedure can be applied to even pretty big molecules. We have also updated our conformation programm and intra molecular interaction programm based on Huran and Claverie's approach.

## Studies on model system of cell-cell and cell-lectin interaction

A. Surolia
IIIM, Jadavpur, Calcutta

Cell surface carbohydrates play a crucial role in cell-cell interactions and have been implicated as receptor for several toxins viruses, hormones, antibodies, lectins etc. Response of a cell towards these external ligands will be determined by the accessibility of the carbohydrate receptor to these ligands as well as by the lateral mobility distribution and local density of the receptors. Interaction of the liposomes containing glycolipids with a galactose binding lectin from castor been provided a model system to investigate the accessibility, topological redistribution of the receptor and the subsequent response of these model cell membranes (liposomes) to external ligands. The binding of castor been lectin ($RCA_1$) to the liposomes containing galactocerebroside was very poor in contrast to the monosialoganglioside liposome which showed a very good binding. On the otherhand, the lactocerebroside showed a slight binding. The poor binding of galactocerebroside may be due to a restricted access of the galactose residue of the galactocerebroside to $RCA_1$, because the single galactose residue of this glycolipid may be buried close to the bilayer. However, incorporation of cholesterol leads to a remarkable increase in the recognition of these glycolipids by the lectin. From these results, a role for the lipid composition and the immediate local environment of the receptor in determining the exposure on the membrane surface has been proposed. The binding of lectin to the $GM_1$ ganglioside liposome results in the aggregation of these liposomes; a process similar to agglutination response of the cells to the lectin. Aggregation of the $GM_1$ liposomes by the lectin increased by a factor of 20 when the density of $GM_1$ on the surface of liposomes increased by a factor of two similarly the fluidization of the lipid bilayer of the liposome by changes in the lipid composition or by anaesthetics like ostanol increased the rate of liposomal aggregation by a factor of four to five. The fact that the effect of fluidizing agents is small as compared to that brought about by density perturbation as reported earlier suggest existence of ganglioside enriched microregions held together by intermolecular attractive forces between oligosaccharide chains arising due to phase separation as a possible factor in controlling $GM_1$ liposome aggregation.

# Targeting of Liposomes to testes using sperm 'Specific' Anti-Lactate Dehydrogenase-X (Anti-LDH-X)

Ateeq Ahmad
Central Drug Research Insitute, Lucknow

The failure of many drungs to act selectively on their target is related to a number of problems which hamper therapy or prevention of disease. It is envisaged that drug targeting could be improved by the use of biodegradable carrier which by virtue of its structural characteristics will transport active agents from the site of injection to the area of action. It appears now that a convenient carrier candidate may be lipid vesicles (liposomes), as a formidable means of controlled drug action. But liposomes injected into the mammalian blood stream are taken up by the liver and spleen. It is known that liposomal surface is an important determinant of liposomes interaction with cellular membrane and that modification of liposomal surface is a potential method of directing liposome encapsulated drugs to specific tissues. We can envisage that tissue/cell specific antibodies conjugated or associated to liposomes may serve as a means of carrying liposomes to desired site of action.

We have isolated a unique sperm 'specific' enzyme located dehydrogenase-X (LDH-X) from mouse testes. This enzyme is both auto- and iso-antigenic. A new procedure for the purification of enzyme was developed which utilizes cibacron blue F3GA dye covalently attached to Sepharose affinity resin. LDH-X binds to this resin at pH 7.4 and could be eluted specifically with 1 mM NADH containing, buffer. To raise antibodies, enzymes was injected in rabbits at different time intervals. Anti-sera raised against LDH-X was subjected to ammonium sulfate fractionation, DEAE-cellulose ion exchange chromatography for the purification of anti-LDH-X melecules. LDH-X molecules were covalently attached to Sepharose and this affinity resin was also utilized for the isolation of anti-LDH-X. In order to check thespecifity of anti-LDH-X and its interaction with LDH-X from several species, tissues from Mouse, testes, Rat testes, Rabbit testes, Mouse muscle and Mouse heart were taken and homogenized. After centrifugation the supernatant was taken and stored, Ouchterlony was carried out to check the purity and interaction of anti-LDH-X with LDH-X and other LDH-X containing tissues, Results showed that this antibody cross-reacts with mouse LDH-X, mouse testes homogenate, Rat testes homogenate Rabbits tetes homogenate. However, it has no interaction with mouse heart tissues and mouse muscle homogenate and thereby showing the absence of enzyme LDH-X in these tissues.

AGRICULTURE

## AGRICULTURE

| | Title of the Project | Name of the Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Inter-institutional Project on 'Genetics of Biological Nitrogen Fixation'. | Coordinator<br>Dr. S.N. Kakar,<br>Haryana Agril. University,<br>Hissar.<br><br>Investigators:<br><br>Prof. H.N. Singh,<br>School of Life Sciences,<br>University of Hyderabad.<br><br>Prof. H.D. Kumar,<br>BHU, Varanasi.<br><br>Dr. P.K. Singh,<br>Central Rice Res. Institute,<br>Cuttack.<br><br>Dr. B.S. Ghai,<br>Punjab Agril. University,<br>Ludhiana.<br><br>Dr. M. Lakshmanan,<br>Madurai Kamraj University,<br>Madurai.<br><br>Prof. V.V. Modi,<br>M.S. University of Baroda,<br>Baroda.<br><br>Dr. J.K. Ladha,<br>Madurai Kamaraj University,<br>Madurai. |
| 2. | Studies on Plant Pesticides. | Dr. Avijit Banerji,<br>University College of Science,<br>Calcutta. |
| 3. | Polyamines in the control of ageing of rice seeds. | Dr.(Mrs) Bharati Ghosh,<br>Bose Institute,<br>Calcutta-9. |
| 4. | Studies on the effect of pollutants on the cellular organelles and cellular processes of plant and animal cells. | Dr.P.C. Kesavan/<br>Dr. Prasanna Mohanty,<br>JNU, New Delhi. |

# GENETICS OF *RHIZOBIUM* FOR BIOLOGICAL NITROGEN FIXATION

S.N. Kakar
Haryana Agricultural University, Hissar

Objectives of the project:

Defining of genes determining nodulation/$N_2$ fixation, competitiveness and survival.

Technical programme:

a) Isolation of appropriate mutants for defining genes for nodulation, $N_2$ fixation and competitiveness.

b) To find out their location on plasmids vis a vis chromosomes.

# Mutational manipulation of $N_2$ fixation in *Nostoc muscorum* and *Anabaena doliolum* with agricultural implications.

H. N. Singh
Hyderabad University, Hyderabad

Objectives:

I. Mutational analysis of interrelations between Aerobic $N_2$- fixation and heterocyst, Nitrogenase, GS, GOGAT and photosynthesis.

II. Production of mutants with better.

(a) $N_2$- fixation ability and (b) the ability to excrete most of the $N_2$- derived $NH_4^+$. The previous physiological and biochemical studies on the mechanisms of aerobic nitrogen fixation in heterocystous blue green algae have clearly shown very tight physiological and biochemical linkage between heterocyst and nitrogenase under aerobic growth conditions and the involvement of active GS in $NO_3^-$ or $NH_4^+$ repression of heterocyst and nitrogenase both. However, the specific role of GS, glutamine, GOGAT and glutamate in the regulation of distinctive steps in aerobic nitrogen fixation process is not very clear at the moment. The proposed genetic analysis of the entire process is expected to provide more sound and definitive knowledge about it and might thus result in the development of methods for genetic manipulations of $N_2$- fixation and their use in agriculture industry. The development and suitable technology for isolating and raising populations of mutants which liberate $NH_4^+$ from fixed $N_2$ would open a new field for their use as Solar energy dirven $NH_4^+$ producing factories in rice agriculture.

Technical programme: During the last 3-4 years some progress has been made in genetics of $N_2$ fixation only in *Nostoc muscorum*. Genetic structure and regulation of $N_2$ fixing apparatus would be the focal point of investigations in the *Nostoc Muscorum* and *Anabaena doliolum*. One junior research fellow would work on isolation of various categories of mutants of *N. muscorum*, the second junior research fellow would similarly be engaged on *Anabaena doliolum*. One Research Associate would analyse biochemically the various $N_2$ fixing mutants of *N. muscorum*. The other Research Associate would carry out similar work on *A. doliolum*.

The brief synopsis of the proposed work is as follows:

1. Isolation of various class of *het* and *nif* mutants under aerobic and anaerobic conditions.

2. Isolation of regulatory mutants of *het* and *nif* genes and their relation with GS and GOGAT activity.

3. Study of the reversion characteristics of various classes of mutants and examination of this property in $No_3^-$, $No_2^-$, $NH_4^+$ and glutamine medium.

4. Isolation of GS and GOGAT mutants for examining the role of these enzymes in the regulation of heterocyst and nitrogenase.

5. Isolation of mutants derepressed for heterocyst and nitrogenase in fixed nitrogen medium and examining them for ammonium excretion resulting from $N_2$ fixation.

6. Development of techniques for isolating better $N_2$ fixing strains. In terms of their (a) Nitrogenase activity and (b) Nitrogen derived $NH_4^+$ excretion by application of inhibitors of photo phosphorylation, ATpase activity all hill reaction as selective agents for mutant production.

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# GENETIC STUDIES ON NITROGEN FIXATION BY BLUE GREEN ALGAE: THE ORGANIZATION OF *nif* GENES

H.D. Kumar, BHU, Varanasi-5.

## Objective of the project:

To elucidate the nature of nitrogen fixation genes (*nif*) of blue-green algae in terms of the following:

(i) Number of genetic units effecting nitrogen fixation and heterocyst differentiation in blue-green algae.

(ii) Allocation of the above genes among neighbouring ones.

## Technical Programme:

Blue-green algae are the only known organisms which combine an exygenic mode of electron generation (Photosynthetically) with a capacity to reduce elemental nitrogen. It is anticipated that elucidation of the nature of nitrogen fixation genes of these organisms will be helpful towards developing a nitrogen-fixing eukaryotic plant through genetic manipulation, since the latter systems also possess a basically similar mode of photosynthesis. As such, it is hoped that the investigations proposed hereunder will provide important clues as to the suitability of blue-green algae as starting material for this objective.

In bacteria, nitrogen fixation genes are thought to be located near the histidine biosynthesis genes. There are *prime facie* indications that this is also the case in blue-green algae. Thus it becomes worth-while to investigate *his* genes in order to make an approach to *nif* (with respect to location and mode of regulation) in these organisms for the following reasons.

(i) Availability of selective methods for isolation of *his* regulatory mutants with the help of histidine analogues.

(ii) Occurrence of genetic variations leading to inhibition of elemental nitrogen dependent growth of certain blue-green algae.

(iii) A convenient spectrophotometric method for assessment of the extent of derepression of *his* genes.

Contd....

The difficulty with blue-green algae, however, is the unavailability of efficient methods of cross testing the different strains for complementation and recombination, although recombination involving a few genetic markers has been reported. With those facts in view, it is proposed to include attempts to find out suitable methods for genetic exchange in these organisms as a part of the present project. A brief outline of the research work to be undertaken follows

A. Standardization of suitable methods for isolation of DNA from nitrogen-fixing blue-green algae where the usual ethanol precipitation has not proved to be very satisfactory. It may be mentioned that transformation in unicellular blue-green algae has been successful and its potential for genetic mapping suggested.

B. Isolation and general characterization of *his* regulatory mutants by selection for resistance to histidine analogues.

C. Kinetic studies on uptake of high molecular weight substances (proteins and nucleic acids) by intact and nude cells (lysozyme-treated) of blue-green algae.

D. Test for complementation among various strains to resolve the inter -and intra-operon relationship and inter-dependence of *nif* and *his* expression.

E. A study of the concomitant effects of the above mentioned genetic alterations on the expression of *nif* in terms of acetylene reduction and presence of immunologically cross-reacting material.

F. Selection of strains of blue-green algae derepressed for nitrogen fixation and study of uptake and fate of DNA isolated from such strains by eukaryotic algal cells and protoplasts.

# GENETICS OF BLUE-GREEN ALGAE NITROGEN FIXATION

P.K. Singh
Central Rice Research Institute, Cuttack

Objective of the project:

To work-out the genetics of nitrogen fixation and heterocyst differentiation in blue-green algae.

Technical programme:

In the proposed project, it is intended to study the genetics of nitrogen fixation in blue-green algae. The following aspects will be considered in detail in the project:

1. The genetical studies carried out at this Institute on Nitrogen fixation and heterocyst differentiation of blue-green algae Nostoc muscorum. Cylindrospermum sp. and Wollea bharadwajae will be intensified. The cyanophage N-1 and other viruses infecting N-fixing blue-green algae will be utilized in the genetic transfer experiments.

2. Attempts will be made to map 'nif', 'het' and regulatory genes.

# GENETIC OF BIOLOGICAL NITROGEN FIXATION BY RHIZOBIUM

B.S. Ghai
Punjab Agricultural University, Ludhiana

Objective of the Project:

Different Rhizobium species fix atmospherie nitrogen in symbiotic association with specific legume species. This biological nitrogen fixation depends upon the genetic make up of both the macro and the micro-symbiont. Although there are reports of transformation, transduction and conjugation in non-nodulating strain of Rhizobium lupini very little genetic studies have been done in Rhizobium. These modes of recombination have not been found suitable for genetic analysis. The recent discovery that the plasmids of P-1 incompatibility group have remarkably wide host range and can be used for inter-specific and eve intergenetic gene transfers lead to the initiation of work on construction on linkage maps in Rhizobium legumi nosarum (Beringer and Hopwood, 1976 Nature 264:29'-93) and Rhizobium melitoti (Kondorosi et al., 1977, Nature 268:525-27)

So far the improvement of biological nitrogen fixation by Rhizobium has been based on induction of mutations. The selection of efficient mutants is very difficult as there are no simple criteria of differentiating the efficient mutants and one has to see actual nitrogen fixation fixation in combination with legume. Under the present situation, the strain improvement through mutations is very difficult and has not produced much useful results. The present investigations aim to:

i). Develop technique of Rhizobium strain improvement through interspecific and intraspecific conjugation with the help of P-' incompatibility group plasmids.

ii) Test the recombimants in the laboratory and field conditions for biological nitrogen fixation and competition.

Contd...

Technical programme:

Several strains of Rhizobium species are available with the investigation incharge. Three strains, carrying three different P-1 incompatibility group plasmids, are also available with him.

i) Auxotrophic and antibiotie resistant mutants will be induced through UV radiation and chemicals.

ii) Three different plasmids of P-1 incompatibility group will be introduced into highly effective strains of Rhizobium differing for days required for initiation of nodulation, adaptability, host range, persistance in soil, resistance to fungicides etc.

iii) Using appropriate antibiotic resistance and auxotrophic markers recombinants will be produced between high officient strains differing for various desirable characters.

iv) These recombinants will be first tested in the laboratory for artificial medium and the highly, efficient recombinants will then be tested in the pots and fields for nitrogen fixation capacity and competition with the native bacteria.

# Genetics of nitrogen fixation in *Azotobacter* species

M. Lakshmanan
Madurai Kamaraj University, Madurai

## Objectives:

Although attempts were made to recognize mitrogen fixing eucaryotic organisms, available information show only procaryotic organisms such as bacteria, blue-green algae and actiomycets fix atmospheric nitrogen. Among bacteria *Azotobacter* is the most widely used freeliving nitrogen fixing bacterium as biofertilizer in the field. However systematic work is necessary to understand the nitrogen fixing capacity and production of hormones by different species and strains by *Azotobacter*.

In the present study several strains of *Azotobacter* will be classified on the basis of their capacity for Nitrogen fixation and their field performance. Attempts will be made to isolate mutant strains with reference to 'nif'. gene cluster and glutamine and glutamate synthesizing regions in order to isolate 'nif' constitutive mutants and to obtain strains that release a fairly large quantity of the biologically fixed nitrogen into the soil. Experiments will be conducted to isolate strains to grow in acidic soils, for high and low temperatures and dry soils.

## Technical Programme:

All species of *Azotobacter* and available strains in India in all the species.

1. Characterising different strains of *Azotobacter* to evolve strains which are capable of efficient fixation of nitrogen at low carbon conditions.

2. Isolation and characterisation of strains with drug resistance markers to be used in other genetic studies.

3. Screening and classifying different strains as highly efficient, medium and poor based on the capacity of strains to fix the atmospheric nitrogen vis-a-vis their field performance.

4. Isolation and characterisation of strains that are 'nif' constitutive. Their capacity to leach ammonia amino acid and peptides will be studied. Their performance in the field will also be a major factor in their selection.

5. The failure of Azotobacter to grow in certain soil types and climatic condition will be studied. Attempts will be made to isolate mutants to overcome the difficulties that would prevent the universal use of the wild type.

6. Characterizing different strains of Azotobacter to isolate strains which are capable of producing plant hormones or converting the substrates to hormones with high nitrogen fixing capacity.

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# GENETIC PROPERTIES OF RHIZOBIUM SPECIES.

V.V. Modi
M.S. University of Baroda

Objective of the Project:

1. Uncovering of regulatory mechanisms controlling nodulation and nitrogen fixation.

2. Studies on enzymes involved in nitrogen assimilation process in Rhizobium.

3. Studies on the mechanism of infection of Rhizobium by its bacteriophage.

4. Further studies on mechanism of genetic transformation in Rhizobium.

Technical Programme:

1. Isolation of various bacteriophage from legume soils of Gujarat State.

2. Determination of Enzyme levels at different stages of nodule development in order to define 'Marker enzymes' which can be used to detect the process of infection and nodule formation.

3. Purification of a competence factor (CF) from Rhizobium japonicum D211 and to study its ability to make other species of Rhizobium transformable (competent)

4. To study various factors that regulate the ammonia assimilation enzyme i.e. GDH (glutamate dehydrogenase) GS (glutamine synthetase) and GOGAT (glutamate synthase) under symbiotic and asymbiotic Nitrogen fixing conditions in Rhizobium.

5. Purification of GS from Rhizobium to homogenity and preparation of antisera to evaluate the role of the Bacterial GS in the assimilation of $NH_3$ in the nodule.

Contd...

6 A study of various factors that regulate the 'Marker enzymes' involved during infection in asymbiotic and symbiotic conditions. And also to study the distribution of these enzymes in the nodule.

7. To study various factors that regulate the formation and production of CF and to understand its mechanism of action in the transport of DNA during genetic transformation. Also to study other steps in the development of competence in Rhizobium.

8. To study the infective properties of the isolated bacteriophages to understand the following -i) Adsorption, ii) Intracellular replication, iii) Dysogeny, iv) Competetiveness amongst Rhizobium, v) Exopolysaccharide structure, vi) Transduction.

# Genetic regulation of heterocyst formation, nitrogen fixation and $NH_4^+$ - assimilation in the Blue-Green Algae

J. K. Ladha
Madurai-Kamaraj University, Madurai.

## Objectives of the project:

Blue-green algae (Cyanophyceae or Cyanobacteria), once a neglected group of microorganisms, are enjoying at present an unprecendented interest in their activities. This is perhaps because of they are the only group of nitrogen-fixing microorganisms that have a higher plant type of photosynthesis with an ability to use water as reductant and thus evolve oxygen.

In tropical countries (like India) rice is a main dietary food. Blue-green algae grow luxuriantly in the tropical rice fields where conditions seem to be most favourable. Most probably these nitrogen-fixing blue-green algae also help augment in the nitrogen nutrition of rice plants. It has also been suggested that it might be possible to increase the yield of rice crops by artificially inocculating the paddy fields with improved strains of nitrogen-fixing cyanophytes.

Although the bluge-green algae have attracted the attention of phycologists, microbiologisits, physiologists and ecologists for more than 75 years and a wealth of information about their taxonomy, morphology, physiology, and ecology has accumulated, however, studies on mutagenesis and genetics of these organisms were started only in the early 1960s. Despite considerable progress our present knowledge of the genetics of blue-green algae is far less than that of bacterial genetics.

## Technical Programme:

### (a) Isolation of mutants:

A wide range of spontaneous and nitrosoguanidine induced mutants from complete and/or partial loss of heterocyst formation, nitrogen-fixing activity, nitrato-reductase activity with resistant and sensitive to different antibiotics (like, streptomycin, polymyxin-B, Crythromycin etc.) will be isolated.

Besides, mutants affecting inorganic nitrogen-assimilation pathways, attempts will also be made to isolate amino acids auxotrophs and mutants resistant to certain amino acid analogous like, L-methinine-Dt-sulfoxinine (MSO) 5-hydroxylisine (HYL). These amino acid analogous inhibit glutamin synthetase (GS), a primary ammonia assimilation pathway of blue-green algae. Therefore, mutants resistant to these analogous would expected to be deficient in glutamine synthetase. Such mutants are very important because earlier it was thought that ammonia, an immediate product of nitrogen fixation acts as a regulator of heterocyst spacing pattern. But now some recent results of genetical studies of blue-green algae have shown that $NH_4^+$ per se is not a regulator of heterocyst spacing pattern. Now the glutamine is an immediate product of ammonia assimilation therefore it could be a possible candidate as a regulator. To solve this problem mutants requring glutamine would be of immense importance.

(b) Characterisation of mutants:

After the isolation of mutants, they will be characterised by a large member of following physiological and genetical characteristics:

i) growth with the without nitrogen source.

ii) nitrogen-fixing capacity under aerobic and microaerobic conditions.

iii) repressibility of heterocyst formation by different inorganic and organic nitrogen sources.

iv) pattern of heterocyst spacing.

v) nitrate and ammonia assimilating enzyme activities.

vi) reversion frequency.

vii) genetic transfer through recombination and/or transformation.

# Studies on Plant Pesticides

A. Banerji
University College of Science
Calcutta

The objective of the present studies is to develop new plant pesticides from indigenous species. These studies would be of economic importance as:

i) These plant pesticides could replace certain synthetic pesticides which possess harmful side-effects.

ii) The development of these pesticides from easily available indigenous plant sources could result in import substitution.

In course of these studies a programme of synthesis of natural pesticides and their close analogues will also be taken up. Particular attention will be paid to gain knowledge about structure activity relationships of the botanical pesticies.

## Work carried out

A number of amide derivatives isolated from the different Piper species, eg piperine (1), were found to possess insecticidal property. The structures of such amides contain invariably a conjugated olefinic systems.

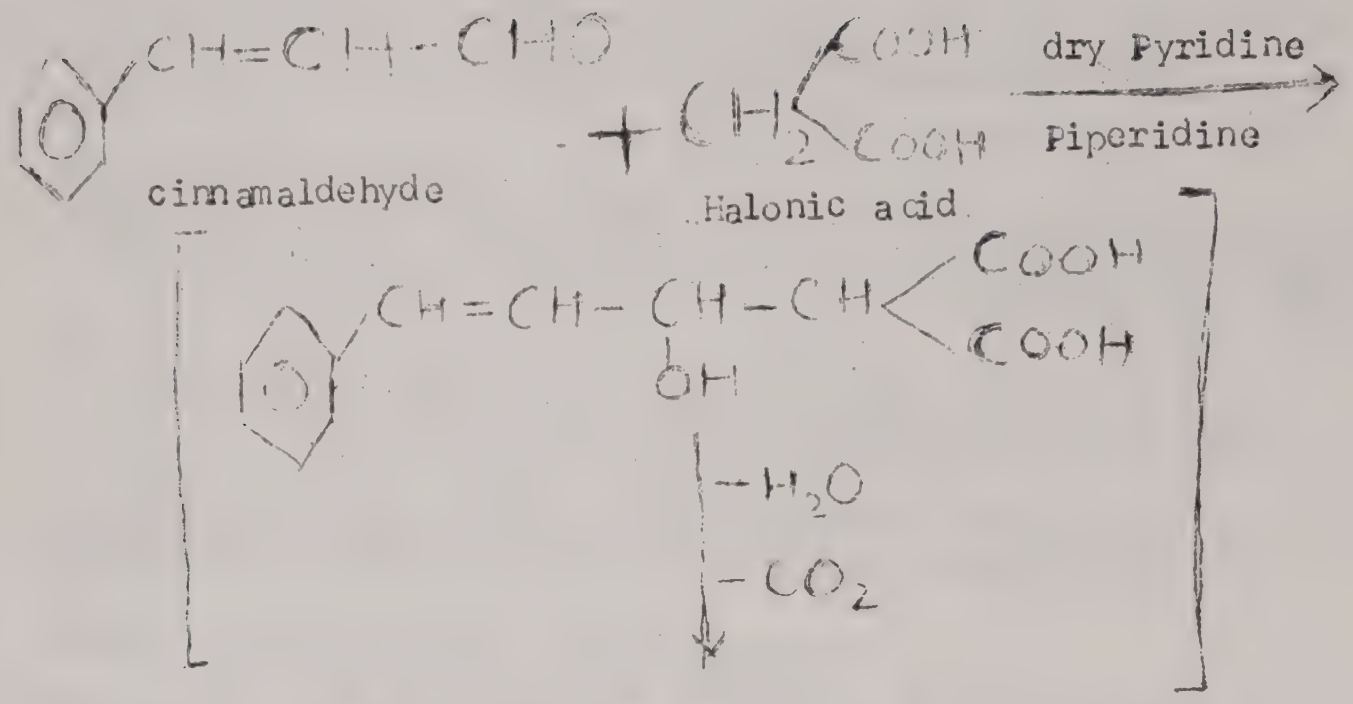


Piperine (I)

Attempts are being made to establish a structure-activity relationship in this respect by synthesizing structural analogues of piperine (I). It is planned to prepare compounds having different substituted aromatic rings and different amine residues. The work done so far in this respect is described below:

The acid (II) was synthesised from cinnamaldehyde, using the

following procedure:




(11)

The crude acid was recrystallised from benzene to give white flakes, mpt 164°C. The structure of the acid was confirmed by its elemental analysis and its I.R. spectrum.

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# Polyamines in the control of aging of rice seeds

Bharati Ghosh
Bose Institute, Calcutta

The activity of arginine decarboxylase of rice seed was determined in different stages of development in different germinating period and also in seeds of different ages. The results obtained indicate that in milky stage, the enzyme activity becomes maximum. It is of interest to find out that enzyme activity increases with the increasing age of seeds. In different germinating stages, it was found that the enzyme activity gradually increases upto 72 hours of germination and then gradually decreased. Similar pattern was obtained regarding the polyamine content. But the work is yet to be finished. Polyamines were separated by gradient elution through Dowex-50 column. The polyamines tested are spermine, spermidine, agmatine, cadaverine, putracine. Also the methods of isolation of tRNA and aminoacyl + RNA synthetase have been standardised to study the amount of +RNA and its aminoacylation capacity in different stages.

# STUDIES ON THE EFFECT OF POLLUTANTS ON THE CELLULAR ORGANELLES AND CELLULAR PROCESSES OF PLANT AND ANIMAL CELLS.

P.C. Kesavan/Prasanna Mohanty
J.N.U., New Delhi -110067.

## Objectives of the project

Although the effect of pesticides, pollutants, Toxic chemicals on the genetic make up of the cells is being extensively studied in many laboratories, there has been no concerted efforts to analyze the immediate effect of environmental pollutant on the bioenergetic organells like chloroplasts, mitochondria and lysosomal systems. This project aims at analyzing the immediate effect of environmental pollutant on bioenergetics of organells as well as on their biosynthetic process. A comparative analysis of energy linked cellular processes in plant and animal cells will provide insights into basic mode(s) of action of some of the environmental pollutants.

Technical Programmes:

Effect of particulate pollutants on plant and animal cells.

The emphasis will be given on the study of basic aspects like the effect of particulate pollutants on the primary processes of chloroplasts and their membrane-linked function. Membrane integrity and stability of coupling activity in both mitochondrial and chloroplasts will be studies.

Objective: To ascertain if these pollutants effect such vital processes like photosynthesis, respiration, growth and development of crop plants.

A. Interaction of pollutants on the bioenergetic organelles like chloroplasts and mitochondria.

   a. In vitro studies will be made with isolated organelles particularly mitochondria and chloroplasts. Hill reaction, $O_2$ evolution and $O_2$ uptake, ATP synthesis will be measured.

   b. In vitro studies with plant leaves and in tact leaves and pot plants (sugar cane and rice).

Contd...

These experiments will be designed to ascertain the nature of inter-action of chloroplasts, mitochondria and peroxisomal systems with toxic pollutants and chemicals. Total photosynthesis, respiration and other metabolic processes will be studied. The experimental results obtained from *in vitro* studies will be correlated with *in vivo* studies.

B. Studies on Biogenesis of plant organells:

a. Germination studies with rice or wheat grains or greening of potted plants such as sugarcane will be attempted. Development of bioenergetic organelles and processes will be essential to ascertain if the effect of pollutant is specific, sequential or simultaneous. Many characteristic parameters like pigments, marker enzymes, membrane-bound carriers can be used to monitor the effect of toxic materials on the process of plant development. Wherever possible comparative studies will be made with animal system to probe the common effect of pollutant on both the systems. Many fluorescent probes are available which monitor specifically membrane energization. We will use such extrinsic probes to monitor the effect of pollutants on membrane function.

b. Turnover studies: The turnover of enzymes and protein is quite diagnostic indication of cellular metabolism. In all probability, these toxic materials not only effect the biosynthetic processes but also induce senescence and degradation. It is quite likely that the presence of pollutant may affect the turnover of many key enzymes and proteins, membrane-bound carriers and pigments and chromophores. Labelling and pulse-chasing experiments will be used as standard techniques. Peroxisomal enzyme turnover will be investigated.

c. Cell biology of peroxisomes of plant and animal cells: Ultrastructural aspects of biogenesis of these organells will be investigated. The possible interference of pollutants with the biogenesis of these organells will receive special attention. This work will be done in collaboration with other scientists as EM facilities are not available in the School of Life Sciences, JNU, at present.

# III

# ENGINEERING & EARTH SCIENCES

1. ENGINEERING
2. GEOLOGY

ENGINEERING

## ENGINEERING

| | Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Inter-institutional project on 'Wind Forces on Tall and Slender Structures'. | Dr. Prem Krishna, Roorkee University.<br><br>Dr. A.K. Gupta, IIT, Kanpur. |

# Study of sub-sonic wind effects on Civil Engineering Structures.

Prem Krishna
Roorkee University, Roorkee

It is proposed in the first phase to study the effect of wind on high-rise towers.

Towers could mainly be;

(a) Latticed steel towers
(b) Concrete towers
(c) Composite towers comprising of concrete towers with steel lattice parts on their tops.

The in-line gust excitation of lattice towers has been studied by Chiu(1) based on the concept of simulated wind profile by generating the artificial wind.

The along-wind response of lattice towers as well as concrete towers may be analysed on the concept of gust spectrum as proposed by Davenport (2). However, the cylindrical circular concrete towers are more prone to accross-wind excitation due to vortex shedding. The nature of the vortex excitation of concrete towers may be harmonic or random depending upon the value of Strouhal and Reynolds numbers. Strongest oscillations arise at wind velocity for which the frequency of vortex shedding coincides with one of the natural frequencies of the structure. For vortex random excitation again the concept of spectrum may be applied for the analysis of the system.

The studies regarding the vortex excitation of cylindrical circular towers have been made by several investigators (3,4,5).

There is some evidence that composite towers are less susceptible to wind effects as compared to a lattice or concrete tower of the same height. However, enough data is not available on the behaviour of such structures.

Another important aspect of wind is the freak occurances like tornadoes. Some analytical study of tornado effects on buildings is available(6) but no analysis seems to have been made of towers under such effects.

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It is, therefore, proposed in the first phase.

i) to investigate analytically the behaviour of composite towers under gust excitation as well as vortex shedding effect;

ii) to study the response of towers- lattice type, cylindrical circular concrete and composite towers to tornadoes.

iii) to carry out model studies of the above in a wind tunnel.

# WIND INDUCED NEAR WAKE OF TALL ASYMMETRIC STRUCTURES

A.K. Gupta
Indian Institute of Technology, Kanpur

Over the past two decades, the need for systematic studies of wind loading and its effects on tall structures has been increasingly recognised. Tall structures by way of thermal power plant chimneys, TV/microwave transmission towers and commercial skyscrapers are also beginning to appear on the Indian terrain as well. However, the National Building Code for Indian conditions prescribes approximate guidelines for static loads only, and leaves enough room to look into other aspects of wind loading. The objectives of the present project are to prepare a 'state of the art' report on wind forces on tall structures, and furthermore to carry out an experimental investigations to determine the near wake structure of tall asymmetric cross section bodies. These asymmetric cross sections are basically square and rectangles of different arms ratios.

On receipt of the first grant from the Academy in January, 1979, the work was initiated. During the one year period, DISA constant temperature hot wire anemometry equipment was acquired through import from Denmark. This equipment is to be used in the experimental investigation. An extensive literature survey was carried out in order to prepare the 'state of the art' report. This is still being continued. An open elective course on the related subject of industrial aerodynamics for the final year degree students was offered during the first semester of 79-80. A short publication on the problem of wind loading on tall structures was reported in the diamond jubilee souvenir of Institution of Engineers Kanpur Branch in September 1979. As second part of this project, an experimental investigation of the near wake flow around two dimensional rectangular cylinders has been started.

Models of one square and three rectangular cylinders of arms ratios 4:3, 2:1 and 4:1 have been fabricated and tested. Preliminary results of smoke flow visualization and static pressure distribution have been obtained.

# GEOLOGY

## GEOLOGY

| | Title of the Project | Name of Investigator(s) and Institution(s) |
|---|---|---|
| 1. | Inter-institutional project on 'Archaean Geochemistry of the South Indian Shield'. | Coordinator<br><br>Prof. C.S. Pichamuthu,<br>Dept. of Mines & Geology,<br>Bangalore.<br><br>Investigators:<br><br>Shri C.N. Venkat Kumaran,<br>Director,<br>Dept. of Mines & Geology,<br>Bangalore.<br><br>Dr. B.P. Radhakrishna,<br>Chitradurga Copper Co.<br>Bangalore.<br><br>Prof. M.N.Viswanathaiah,<br>Mysore University,<br><br>Dr. S. Ramasheshan,<br>National Aeronautical Lab.,<br>Bangalore.<br><br>Dr. M. Sankar Das,<br>BARC, Bombay.<br><br>Prof. V.S. Venkatasubramanian,<br>IISc, Bangalore.<br><br>Prof. U. Aswathanarayana,<br>Saugar University(M.P.)<br><br>Sri R. Srinivasan,<br>Geomysore Services,<br>Bangalore. |
| 2. | Studies on the Indian Monsoon. | Dr.R.Ananthakrishnan,<br>IITM, Poona. |

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# ARCHAEAN GEOCHEMISTRY OF THE SOUTH INDIAN SHIELD

C.S. Pichamuthu
Bangalore

1. The main object of this project is to determine the age relationship and evolution of the Archaean rocks of South Indian Shield.

2. Five areas in Karnataka have been selected in the first instance for critical study, especially as regards their geological and geochemical characteristics.

3. To begin with, the kaldurga-Tarikere Valley gneisses in the Chikmagalur district, were selected for intensive study to determine the relationship between the gneissic pebbles in the Kaldurga conglomerates and the gneissic rocks in the adjoining Tarikere valley. Field, petrographic, and geochemical studies in this area have resulted in proving that the pebbles in the conglomerate were derived from an earlier gneiss and that the gneisses in the Valley have resulted by later remobilisation of the precursor gneiss.

4. The ultramafic belt in the Nuggihalli area was also studied in some details, especially its geochemistry. Among other things, this has shown that the crustal thickness increases from south to north. The value of Ca/Al ratio of the ultramafic rocks here indicated komatiitic affinity towards the south of the belt.

5. An area of about 300 $Km^2$ in the Javanhalli Schist Belt has been geologically mapped on 1:31680 scale, and 654 samples have been collected for geochemical investigations.

6. The Jampalnaikankote granite in the Chitradurga district has been investigated in some detail to determine its mode of emplacement.

7. Reconnaissance surveys have been conducted in the Ghatti-Hosahalli area in the Chitaldurg district, and in the Turakanambi area in the Mysore district, where new occurrences of gabbroic-anorthosite have been discovered.

# Mineralogy and Utilization Technology of Laterites and Bauxites of Western India

K.S. Balasubramaniam
Indian Institute of Technology, Bombay

The object of the project is three fold. (1) To determine and establish the mineralogy of laterites and Bauxites of Western India by using modern techniques. (2) To determine the various physical properties and technical parameters of these laterites and Bauxites. (3) Based on the above data the correct usefulness of these laterites and bauxites will be spelt out in industries particularly with reference to Small Scale utilization in rural and semiurban areas.

Geological field work has been carried out first in and around Belagaum and then around Vengurla (48 E/9). The field work has yielded valuable information regarding the parent rock, altered zone, clay and the occurrence of laterites/Bauxites. Systamatic sampling has been collected from various profiles. The criterion for a profile is in which complete altered sequences are seen. Basalt (parent rock)→Altered Basalt →clay or without clay → Laterite → Bauxites are seen as sussesive stages of 'in-situ' weathering. The slope escarpment and other features are noted. Sampling has been collected by adopting standard methods viz 1) pit sampling 2) Grab sampling 3) Stack sampling 4) Random sampling etc.

Nearly 12 profiles are studied with reference to its geological setting in these thickly vegetated areas. Besides big block samples are collected for utilization aspects of studies. Selected regions soil samples are also collected for geotechnical studies. In all about 200 samples have been collected in this part of field work. Based on the field studies geological map and sections are being prepared.

# A Detailed study of the Lesser Himalayan Sedimentary Belt and the Central Crystalline Axis of Kumaun Himalaya

A.R. Bhattacharya
Lucknow University, Lucknow

(1) The Lesser Himalayan Sedimentary Belt and the Central Crystalline Zone has been studied on a regional basis.
(2) Hemmed in between the Main Boundary Fault in the south and the Main Central Thrust in the north, the mighty sedimentary pile has been found to show the development of two belts - an inner (Tejam-Pithoragarh) belt and an outer (Naini Tal) belt separated by the Almora Crystalline Zone; the latter has been shown to be younger than the former.
(3) The relatively less worked out and rather controversial inner sedimentary belt, with more than 8000 metres thick shelf-platform sediment (late Precambrian - early Palaeozoic) has been shown to be constituted of four conformable formations only, each representing a definite lithofacies assemblage: (i) Hatsila Formation (oldest, usually argillaceous, base not exposed), (ii) Kapkot Formation (calcareous, with stromatolites & magnesite (iii) Saling Formation (phyllitic, represents transitional facies), and (iv) Berinage Formation Formation (youngest, arenaceous with basic volcanics).
(4) Both the inner & outer sedimentary belts (i) are autochthonous, (ii) do not show regional or near-regional inversion of strata, excepting very rarely, at the contact of two different formations only and that too on very local scales, and (iii) show a simpler a structural architecture with mostly E/ESE-W/WNW trending open synclines & anticlines, usually showing more compressed northern limbs than the southern ones.
(5) Calculation of percent flattening in meso folds & mathematical treatment of other structural data, though applied for the first time in the Himalaya, led the author (i) to develop a new concept that the thrusts in tectonically distured areas can possibly be represented by some mathematical equations and (ii) to develop a new technique for precisely locating thrusts in such areas.
(6) Thus, the classical view that the 'thrusts' bounding the Lesser Himalayan crystalline masses of Almora, Baijinath, Askot and Dharamgarh, are the extension & prolongation of the Main Central Thrust, implying the former to be the remants of a gigantic recumbent nappe with roots in the Central Crystalline Zone of the Greater Himalaya, has not been found to hold good anymore. As such, these crystalline masses appear to represent portions of the ancient basement which have been incorporated and folded-in with the strata of the sedimentary belt and later on possibly heaved up along some fault planes, which have since been reactivated and modified.
(7) A detailed study especially of (i) stromatolites, (ii) correlation of sedimentary formations & major tectonic planes with some new (mathematical) angles, (iii) possible structural control of economic mineral localisation, especially magnesite, and (iv) Neotectonics, is proposed.

Staff engaged in Basic Sciences Unit at the
INDIAN NATIONAL SCIENCE ACADEMY, New Delhi

| | | |
|---|---|---|
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| S. P. Sharma | — | Assistant |
| S. S. Mathur | — | Assistant |
| P. K. Vohra | — | Jr. Stenographer |
| Viri Singh | — | Typist |
| Vikram Singh | — | Helper |
| Nathu Singh | — | Helper |

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